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# LECTURE.

Friday, February 12th, 1875.

MAJOR-GENERAL SIR GARNET J. WOLSELEY, K.C.B., G.C.M.G., &c., &c., in the Chair.

## MILITARY BRIDGE-CONSTRUCTION.

By Lieut.-Col. ARTHUR LEAHY, R.E.[1]

WHEN a nation has decided to be prepared for war, the indispensable conditions are—

1. To enrol and train men to fight.
2. To provide *matériel* for their equipment.
3. And supplies for their maintenance.

These conditions being fulfilled, and war being decided on, one of the first military points which will necessarily come under the consideration of the General appointed to direct the war, is the *communications* of his Army; this consideration will, when the General is free to choose the theatre of his operations, largely influence his choice, and when not so free, the establishment and maintenance of his communications will be his first care. By communications are usually understood roads, railways, canals, and telegraph lines; but in the case of an insular power the first communications for the purpose of offence, are necessarily exceptional, and are established and maintained by the Navy.

It is one of the functions of an engineer to direct the works necessary for establishing and maintaining the first mentioned communications, and of these works none are of greater importance than bridges; hence it arises that "military bridge-construction" is one of the duties which a proportion of every military force should be specially trained to undertake.

In our own Service the subject has not, until a comparatively recent date, received the attention it deserves. Our recent wars have happily

[1] The publication of this lecture has been unavoidably delayed.

not been near home, our first lines of communications have been provided by our Navy, and in the only European expedition in which within the last 60 years our army came into collision with that of a Continental Power, we did not move a dozen miles from our ships. Yet who can read of the expedition to the Crimea without being impressed with the fact that many precious lives and much treasure were unnecessarily expended from the want of means, prepared beforehand, for establishing and maintaining our military communications. By a happy chance no serious inconvenience resulted from the want of a military bridge-equipment, for although no important rivers ran across the track of our Army, and the streams which had to be passed were, partly owing to the season of the year, in many places fordable, yet had the bridges which did exist, been demolished, and the fords been obstructed, the case would have been very different. I can testify to the anxiety that was felt when, entirely destitute of any bridge-equipment, we approached those streams; and I do not hesitate to say that had resistance been offered to the crossing of the Belbec and Tchernaya, and the aqueduct parallel to the latter stream, we should have been much embarrassed from want of preconcerted means for passing troops across a few yards of deep water.

There is not any speciality that has, throughout the period from which military history dates, preserved its importance more constantly in relation to the operations of war than "bridge-construction." It influenced such operations ages before many of the arms and appliances now in use were thought of, and the necessity for its study and practice is now as great, if not greater, than ever.

In railways a new element of immense military importance has arisen, and I need scarcely say that for railways, bridges are more indispensable than they were for any pre-existing communications.

Military bridges are of two classes—

1. Those formed on floating supports or piers.
2. Those of which the supports are fixed.

They may be wanted to complete the communications of an army where no bridges exist, where permanent bridges have been destroyed, or require to be supplemented either with the object of separating the combatant troops from the baggage of an army, or because the roads or tracks leading to the bridges, admit of the advance of troops on a larger front than the width of the permanent structure.

In such cases, one or more temporary auxiliary bridges may be wanted for each road, and these, by increasing the means for rapid movements,—now so essential in military operations,—may contribute largely to success.

It would be beyond the scope of this lecture to dwell at any length on the influence of bridges on strategic or tactical operations, and I can, therefore, only call attention to a few important examples of bridges which have been constructed for military objects.

The first military floating bridge of which we have any detailed account, is that constructed by Xerxes more than 2,355 years ago, and over which his host, estimated at above five millions of souls, were, during seven successive days and nights, marched into Greece:

but this, however, would appear to have been preceded by other important bridges constructed by the Persians across the Thracian Bosphorus, and the Danube.

The bridge across the Hellespont was about $1\frac{1}{2}$ miles long; there were two roadways, one formed of 360 ships or boats, the other of 314. One of these roadways was set apart for the combatant troops and the other for the attendants and baggage animals. In each case the vessels were connected by enormous cables, stretching from shore to shore, which were tightened by windlasses on either side, and superlaid with planks, brushwood, and earth, formed the roadway. It may not be without interest to some of my military audience to remind them that the first attempt to construct this bridge failed, owing so far as I can discern, to the neglect of one of the simple principles of bridge-construction, and that this first failure cost the bridge-constructors their lives.

We also read in Xenophon that Cyrus found bridges across the Mæander and Tigris, the former being composed of 7, the latter of 37 boats.

Skins inflated, or filled with hay, were used for crossing rivers by the Greeks, notably by Alexander the Great for the passage of the Oxus. Casks were used by the Romans on several occasions for a like purpose. It was also customary for the Romans to carry with them small boats, together with planks, nails, and ropes, for crossing rivers without loss of time.

Of fixed bridges, the first notable example is that constructed across the Rhine by Cæsar. I produce a model showing how the trestles of this bridge, which was of great strength and solidity, appear to have been put together. It took ten days to construct.

There are numerous instances in which the Rhine has been bridged for warlike operations.

The passages of that river, for purposes of attack by Jourdan in 1795, and by Moreau in 1797 and 1800, are celebrated.

Moreau's passage in 1797, is stated to have been one of that great General's most remarkable enterprises, and was thus effected:—

His Army, some 60,000 strong, shared with that of Hoche, some 70,000 strong, the possession of the left bank of the Rhine from Kehl to Dusseldorf, and the two Generals were ordered to operate simultaneously against the Austrian forces on the right bank in order to create a diversion in favour of Napoleon, then engaged against the Austrians in Italy. Hoche crossed the Rhine without difficulty at Nieuweid, where he had a footing on the right bank, but Moreau had to cross in face of the enemy.

He therefore collected about 60 boats, 40 of which were brought down the Ill, on the dark and stormy night of April 19–20, 1797, with the intention of being used to pass troops across the river at dawn, and thereby surprise the Austrians. The boats were, however, delayed by grounding on a sand bank, and only 25 were forthcoming at 5 A.M., on 20th April, when a fresh delay arose. In the Ill, which was shallow, the boats were poled along. The oars, necessary in the Rhine, had been stowed in one of the boats which had grounded.

An hour was lost in procuring them, and meanwhile, the idea of a surprise had to be abandoned.

The French flotilla, on arriving at the Rhine, found itself in view of the Austrian batteries, which commenced to fire on it. The pontooneers, however, who managed their boats with skill and coolness, succeeded in landing the troops out of grape-range, and went back for other detachments. The French troops sustained themselves on the right bank until reinforced by troops, thrown across:—1stly. By a flying bridge, which was subsequently destroyed by artillery fire. 2ndly. By a floating bridge constructed between 6 P.M. and midnight on 20th April. This latter bridge was, with difficulty, formed under artillery fire from the Austrian batteries.

When this bridge was completed, the troops of Moreau's Army were in a position to take the offensive, which they did, and the operation ended in the retreat and route of the Austrian forces.

The military history of the 17th, 18th, and of the early part of the present century, abounds in examples of important uses made of military bridges. I will now only mention a few of those which appear worthy of special notice.

A bridge 380 yards long, constructed across the Danube at Deckendorf (1740), remarkable for being withdrawn by wheeling it entire along the bank ("swinging bridge" is the technical term used) after the rear-guard of the Army, when closely pressed by the enemy, had crossed it in retreat.

The bridge across the Limat, between Lake Zurich and the Aar, formed (1799), in two and a-half hours, under fire of a Russian force. The bridge was about 100 yards long, and the operation was covered by a detachment previously sent across the river in row-boats.

At the same time Soult forced a passage across the Linth, between Lakes Zurich and Wallenstadt, his troops being passed across on flying bridges, covered by a selected company of expert swimmers, who had been trained to swim, armed with pistols and sabres.

In the spring of the following year (1800), Moreau forced a passage in the face of Austrian troops, across the Rhine, near Lake Constance, a little below Stein. It was intended to have formed the bridge at night, but owing to delay in the arrival of troops, this was not possible, and the bridge was made in the early morning, under cover of artillery fire. By 9 a.m., all Moreau's corps, numbering three divisions and a reserve of cavalry, had passed over it, and were formed on the right bank. In this case the pontoons were carried by hand over ground not practicable for wagons, and the operation is remarkable as showing the importance of having a bridge-equipment capable of being used as boats, and at the same time not too heavy to be carried by hand.

The bridge constructed in 1814 across the Adour, from the left wing of the Duke of Wellington's army, and of which there is a model in this institution, ranks high in importance and interest. It was constructed of boats and cables, on the same principle as the bridge of Xerxes already described.

The passage of the Berisina, during the retreat of Napoleon from

Moscow in 1812, affords one of the most remarkable instances of the importance of maintaining a bridge-equipment as part of the materiel to be moved with the advance of an army, and is also an example of valuable services rendered by Pontooneer corps in constructing improvised bridges under circumstances of peculiar difficulty.

During the month of November, 1812, Napoleon, in his desire to reduce to a minimum the inconvenience of a long train of baggage, ordered a large number of wagons to be destroyed.

Among these, was included his pontoon equipment, which, against the remonstrance of General Eblé, the Officer charged with the direction of the bridging operations of the Army, was burnt.

General Eblé, foreseeing the difficulties likely to arise from this proceeding, gave orders that every pontooneer should carry with him some kind of implement, or nails, useful for bridging operations, he also managed to retain two forges and six wagons, containing tools and ironwork, from the wreck for his train, and, with remarkable foresight, he added some charcoal for his forges.

Napoleon's march was directed to the Berisina, and he made his plans to cross that river by the bridge at Borisow, which was then held by his troops; but, on 23rd November, he received the news that his troops had been repulsed, and that the Russians were in possession of the bridge which they afterwards burnt.

The Russians, who were in great strength on the right bank of the river, expected that Napoleon, checked at that point, would endeavour to pass the river below Borisow, and directed their attention to the lower Berisina, while Napoleon, with great judgment, decided to attempt the passage some leagues higher up.

On the 24th November, Napoleon sent for General Eblé and explained his plans. The Berisina, at the point where the passage was decided on, was less than 100 yards wide. The greatest depth was from six to seven feet, the bottom was muddy, the current moderate, and loose ice drifting down.

Had one-tenth of the bridge equipment which had been burnt a few days before, been available, the passage of the river would have been a simple matter.

In the absence of this equipment, bridges had to be improvised, and had it not been for the foresight of General Eblé, this would have been impossible.

It was decided to construct two trestle bridges; one a light bridge for infantry, and a stronger bridge for artillery and for baggage.

General Eblé lost no time in setting his pontooneers to procure materials for the bridges from the neighbouring village of Studianka. Trees 16 to 17 feet long and 5 to 6 inches in diameter, and timber procured by the destruction of the village, were the available materials.

By about 5 P.M. on 25th November, 46 trestles were prepared, 23 for either bridge. In order to place the trestles, the pontooneers had to work by night in the water, the ice forming around their limbs, adhering to their flesh and causing intense pain. By 1 P.M. on the 26th November, the light bridge was completed, just in time to enable about 7,000 men to be passed over the river, to hold in check the advance of the Russian troops, who, on the discovery of the attempt, had begun to move towards the point at which the bridges were being erected. The flooring of this bridge was formed of light planks taken from the houses, and it was barely passable for horses. A few light guns and some ammunition-wagons were, however, passed over by hand.

By 4 P.M., the bridge destined for carriages was completed, and the artillery and other wagons began to cross. Many of the trestles and the roadway of this bridge were composed of round timber rudely fitted with axes, and the movement of the carriages on so rough a surface, and the pace of the horses, which, notwithstanding orders that had been given to the contrary, were permitted to trot, caused the most violent shocks to the bridge. The trestles sunk unequally in the muddy bottom and eventually some of them gave way, and the traffic was several times interrupted.

The pontooncers worked by reliefs throughout day and night, and with wonderful devotion and endurance of cold and fatigue, managed to repair the bridge, so that during the 27th and 28th November, the troops and a number of followers, and a portion of the baggage of the Grand Army, were, notwithstanding the attacks of the Russians on both banks of the river, passed across in safety.

Segur, writing of this exploit, observes that the exertions of the pontooneers "sauva l'Armée," and Thiers says of General Eblé, who, with a large number of his devoted pontooneers, shortly afterwards succumbed under the hardships they had endured, that he crowned his career by an immortal service. ("Allait couronner sa carrière par un " service immortel.")

## *Russian War*, 1854–6.

During the war with Russia, 1854–6, floating bridges were made use of to cross the Danube. A raft-bridge with carriage and footway was formed by the Russians near Galatz.

A bridge of boats 970 yards long, was formed, by detachments of British and French engineers and British sailors, between Rustchuck and the Island of Mokan, and a trestle bridge connected the latter island with the main land. Over 100,000 men crossed and re-crossed this bridge.

The raft-bridge thrown across Sebastopol Harbour with remarkable rapidity in August, 1855, and removed in the following month after the garrison had retired by it, was 1,000 yards long and 17½ feet wide. It enabled the Russian reserves to be kept secure from the effects of the fire of the siege guns by day, while at the same time they were at hand in case of assault, or for purposes of night attack.

During the embarcation of the British and Sardinian forces at Balaclava Harbour, numerous cask-bridges were formed between the ships and the shore, by which troops, horses, and stores were brought up to the ships' sides, and the embarcation was thereby very much facilitated and expedited.

*Indian Mutiny*, 1857-9.

The river Ganges was on three separate occasions crossed by the Oude Field Force during the rainy season of 1857.

July, 1857. On the first occasion the troops were ferried across in boats, an operation which took eight days.

August, 1857. On the second occasion, the distance was shortened by the construction of a causeway and pier a mile in length, and three bridges, of four, six, and twelve boats across some narrow channels, and the actual passage of the river was completed in one day.

September, 1857. On the third occasion, the communication was completed by a bridge, 1,090 feet in length, composed of 74 boats with improvised superstructure, anchors, and cables. It was constructed by undisciplined workmen and labourers, under the direction of engineer officers, in 42 working hours. In this case the force marched across in a few hours.

*Italian War*, 1859.

A bridge of 97 river boats was constructed under the orders of Prince Napoleon, on the Po, at Casalmaggiore.

*American Civil War*, 1861-63.

From the Civil War in America, 1861—63, may be dated a new era in military bridge-construction. In that war for the first time, arose the necessity for the hasty restoration of railway bridges in connection with military operations; and of the works carried out, the most notable is the trestle bridge across the Potomac Creek on the Richmond, Fredericksburg, and Potomac Railway. This bridge, the trestles of which resembled the model before you, required in some places three tiers of trestles, each about 20 feet in height.

This and most other forms of military railway and other kinds of temporary bridges, are fully described in the valuable work on Military Bridges, published in 1864, by Colonel Haupt, formerly chief of the Construction-Department of Military Railways in the United States' Army.

In this text book, much of the technical information given by Sir Howard Douglas is reproduced corrected to date, and with the addition of the important experience of the author.

The general success which attended the bridging-operations of the Americans during the Civil War, is admirably illustrated by an exceptional case of failure producing most serious results. This occurred when Burnside crossed the Rappahannock, in face of Lee's position overlooking Fredericksburg, with a view to making a direct attack on the Confederate lines, and, as is well known, one of the most crushing defeats of the war, entailing a loss of over 10,000 men, there occurred.

General Franklin, one of the corps' commanders, on whom the most important share of the action fell, officially stated before a Committee of the Senate, held at Washington:—That this disaster resulted from the delay in the arrival of the pontoon-bridges, and that whoever was responsible for this delay, was responsible for all the disasters which followed.

*Danish War*, 1864.

During the Danish War, 1864, a bridge, 280 yards long, was constructed over the Schlei in $2\frac{1}{4}$ hours.

Troops were also thrown across to the Island of Alsen at night, *under fire*, in rafts each of two pontoons. Light artillery was also taken on the rafts.

The crossing took place at four stations, where the river was respectively 700, 900, 1,000, and 2,500 paces wide.

*Austrian War*, 1866.

Previous to this war, Prussian Officers had reconnoitred and measured the permanent bridges likely to be destroyed, and materials for their repair were prepared and fitted together beforehand.

Some of the bridges were subsequently repaired with these materials.

After the battle of Sadowa, the Austrian Army under Benedek, was saved from ruin by 6 strong pontoon bridges thrown across the Elbe, in the rear of the position.

*German War*, 1870–1.

The important services rendered by the bridge-trains attached to the German Army corps during the war of 1870–1 can best be appreciated by a glance at the Table in the Appendix which gives particulars of some of the bridges actually constructed.

The first important occasion on which bridges were required, was at the battle of Wörth. Early in that action the necessity for providing means of crossing the Sauer arose, but the bridge train of the XI Army Corps had, against the remonstrances of the Commanding Officer of Engineers, been left in the rear.

Delay and loss consequently occurred in crossing the river; foot-bridges were, however, improvised out of hop poles, and later in the day regular bridges were constructed, the pontooneers were, during the construction of these bridges, harassed by sharpshooters in the neighbouring houses.

*Ashantee War*, 1874.

It is exactly one year since, in our latest war, Sir Garnet Wolseley recrossed the bridge over the Prah, after the capture of Coomassie.

The events of that war are fresh in your memories, and were a few months ago graphically described at this Institution by principal actors therein.

The total number of bridges constructed during the war, was over 250.

I invite attention to the examples of bridge-construction used, of which models and diagrams are before you. These bridges were, as it is right they should have been, simple in character; and they were not required to carry any very heavy loads. Merit, greater than often attaches to more extensive works, is, however, due to the bridge-constructors, under whose direction the bridges were erected, inasmuch as they were put up under difficulties of no ordinary kind, with very small means both in men and materials, and with few of the appliances usually considered necessary for such works.

Of the bridges constructed during this war, by far the most important was that across the Prah, and the following account of the arrangements made for its construction has been given by Lieut.-Colonel Home, C.B., the Commanding Royal Engineer of the expedition:—

*Bridge across the Prah.*[1]

On arriving at the Prah, it was found that the stream was 189 feet in width, the depth varying from 3 to 10 feet.

Four small Blanshard's pontoons were the only means available for crossing, and were far too few to rely on, for the vast number of carriers that had to pass to the front.

Twelve trussed-girders, each 30 feet long, had been prepared at Chatham. These were very light and strong, and, with 5 supports, would give a bridge across the river 2 feet 6 inches wide.[2] But considering the very important link in the communications this bridge would be, it was determined to make it not less than 5 feet wide.

Thus, the trussed-girders would give one-half of the roadway required, and the remainder consequently had to be made up of material to be procured on the spot.

At Cape Coast Castle, some light trestles had been prepared, but examination showed that they would not be nearly strong enough.

A section was made of the river which showed that the bottom was fairly regular, and of hard sand. There were no means of driving piles, and such light trestles as the tackle on the spot would get out, would undoubtedly be carried away in a short time, as the current was running nearly four miles an hour, and freshets were to be expected.

Under these circumstances the use of crib-work piers was determined on.

On the 26th December, 1873, a rope was got across the river, so as to haul the pontoon-rafts backwards and forwards. This rope served also to keep off any drift-timber that might float down the stream, from damaging the bridge.

A place for the bridge was definitely selected, and a party put on to cut the bank down in a ramp, a considerable work, as it was 30 feet above the water.

The place selected for the bridge was below a projecting point on the bank, which produced a small eddy; this eddy was selected as a convenient place for launching the cribs.

A stake was fixed in each bank so as to mark the centre line of the bridge, and a take-off was prepared by fixing a trestle in the water as deep as the men could work, or about 5 feet; this take-off, spanned

[1] Models of this and of several other forms of bridge-construction are in the Museum (presented by Colonel Leahy).

[2] The trussed-girders were the development of a girder which had been proposed in 1856 by Major-General Bainbrigge.

about 9 feet, and was made of rough timber, and as strong as it conveniently could be. A crib was then constructed on ways; it was 8 feet by 6 feet, at the bottom, and battered up to 4 feet by 3 feet at the level of the water.

Two anchors were laid out, and barrels were attached to the crib to give it some additional buoyancy, the timber being very heavy, four sand-bags were filled, and lashed one in each corner of the bottom, which was composed of a cross-barred frame. These sand-bags and the barrels caused the crib to float vertically.

The bight of the cable between the anchors was adjusted so as to be nearly 30 feet clear of the shore-end (see Plate XXXI); a buoy with a block was attached; a rope rove through the block as a haul out; a rope was carried to the other side of the river, and the crib was launched down the bank, a preventer rope being passed round a tree at the top of the bank to keep it from going too fast. It was found to float generally 2 feet out of water.

The haul-out was manned, the crib hauled up to the block on the bight of the cable, and then allowed to drop slowly down to its position; a rope 28 feet long was attached to the shore-end of the bridge, so as to allow a bearing of 1 foot at each end, and so soon as the crib got into its proper position, the pontoon-raft, loaded with sand-bags, came close up, the slip-knot attached to the barrels was let go, the barrels floated up, and sand-bags were thrown into the crib, mixed with rice-boxes and bread-bags (there were only 100 sand-bags available.

The day after the first crib was launched, it was found to have sunk 17 inches into the mud, and to be only 4 inches out of level; this was easily made up by putting a couple of thick sticks on the low side.

The crib was raised to its full height, and transoms of roughly-adzed timber laid on. The girders were next got into position, and the first span of the bridge was thus completed.

The Major-General having directed that the bridge should not be gone on with until his arrival, nothing further was done with it until his arrival on the 3rd of January, when it was begun at both ends, and finished on the 5th. The spans, where native timber was used, were reduced to 20 feet, as nothing was known of the bearing power of the timber.

The third crib from the south bank, and consequently the middle of the river, was the only one that gave any trouble.

It grounded on a large stone, about 3 feet out of the proper line, and could not be got to float over this stone, although a considerable lifting-power of barrels was applied to it. It was therefore loaded, and the roadway formed over it, the top being levelled up with thick timber on the low side; next day, this crib was found to have slipped 15 inches out of its place; to secure it temporarily it was strutted with piles. The shore side on the north bank was carried on three trestles made of rough timber lashed and braced together. (See Plate XXXII.)

The bridge should have been finished on the 5th, at 10 A.M.; it was not, however, completed until 3 P.M. the same day, when the rear-

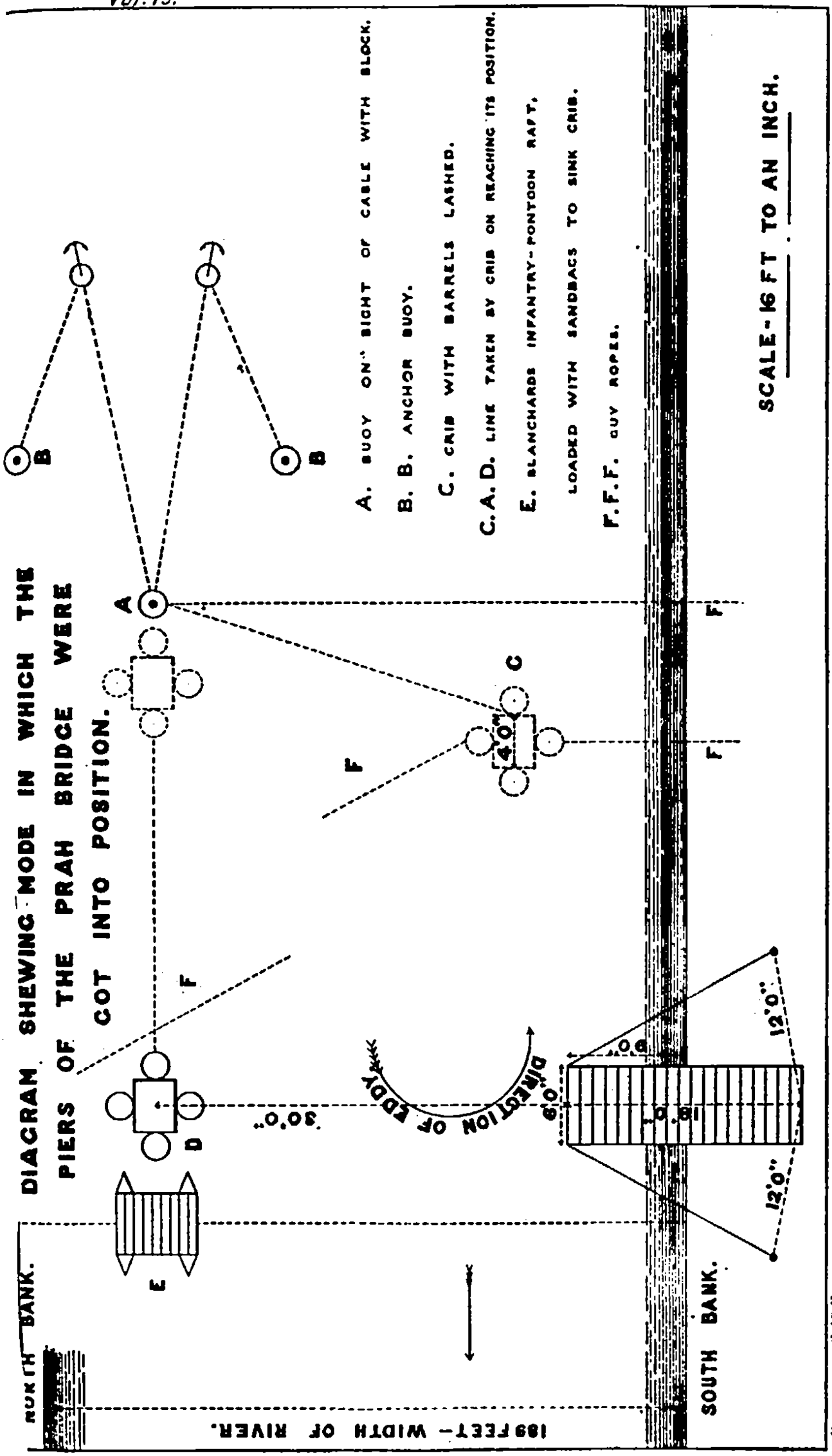
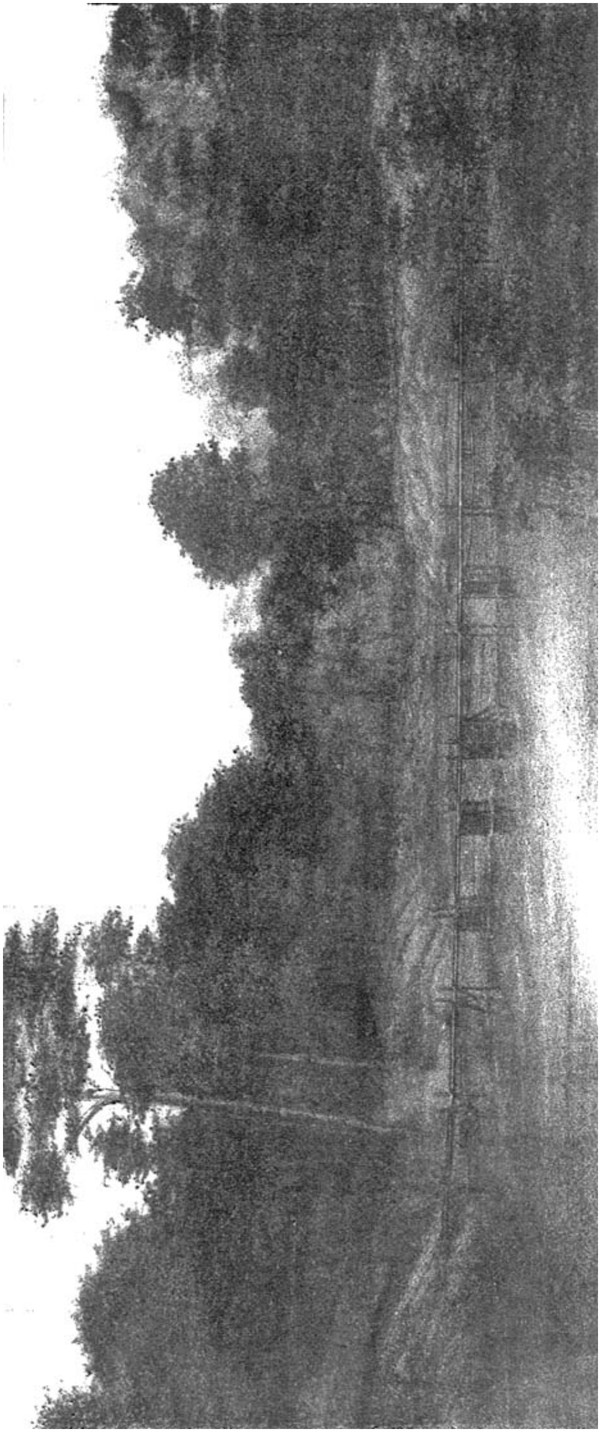


DIAGRAM SHEWING MODE IN WHICH THE PIERS OF THE PRAH BRIDGE WERE GOT INTO POSITION.
A. BUOY ON BIGHT OF CABLE WITH BLOCK.
B. B. ANCHOR BUOY.
C. CRIB WITH BARRELS LASHED.
C. A. D. LINE TAKEN BY CRIB ON REACHING ITS POSITION.
E. BLANCHARDS INFANTRY-PONTOON RAFT, LOADED WITH SANDBAGS TO SINK CRIB.
F. F. F. GUY ROPES.
SCALE-16 FT TO AN INCH.
NORTH BANK.
SOUTH BANK.
189 FEET - WIDTH OF RIVER.
DIRECTION OF EDDY
30'0"
4'0"
6'0"
18'0"
12'0"
12'0"
A
B
B
C
D
E
F
F
F
F



guard and baggage of Russell's regiment moving to the front, passed over it.

The crib that was out of place, showing symptoms of moving, it was relieved by driving strong piles on each side, and the roadway was carried on a cross transom lashed to these piles.

The crib was thus useless, and might have been removed, but it did no harm, and was left in its place. The cribs were all finally lashed with a 3-inch hawser, the roadway secured with telegraph-wire and 10-inch spikes; each crib was further strutted on the down-stream side and an apron of sand-bags and rice-boxes thrown in to prevent any movement; a hand-rail was subsequently added.

On February 11th, 1874, a report was sent to the front to say that the Prah was rising rapidly, and that the bridge was in great danger, but happily on exactly this day twelve months, all anxiety on this score was removed; although the flood rose nearly to the roadway, the bridge was six weeks after, apparently in the same state as when completed, and did not appear to have suffered at all.

The entire number of working hours taken in making the bridge was 61.

The Royal Navy helped greatly in the construction of the bridge, there being only five sappers fit for duty at the Prah.

## *Military Bridge-Construction.*

The conditions to be borne in mind in constructing military bridges, together with the details of the loads due to the passage of troops of various arms, guns, &c., and the formula for calculating the strength and buoyancy of the materials are given fully in our text book on military engineering, from which I have abstracted most of the technical details given in this lecture.

A very convenient epitome of the information required in the field is given in the "Soldier's Pocket Book."

The following points should be borne in mind when constructing military bridges:—

1st. In whatever formation troops are to pass, the bridge should be capable of carrying them when crowded.

2nd. A roadway 8 feet wide in the clear, will admit of the passage of infantry four deep, and of all descriptions of military wagons in one direction, but the width between the hand-rails should not in any case be less than 9 feet; a wider roadway is, if the supports of the bridge admit of it with safety, very desirable, so as to allow Staff Officers or orderlies to pass in a direction contrary to the stream of traffic. In very light bridges, more especially in suspension bridges, the width of the roadway may have to be reduced to the minimum necessary for the wheels of the carriages that have to pass over it, guides being fixed for the wheels. It must be borne in mind that parts of wagons extend beyond the wheel track. The width of a double roadway should not be less than 16 feet. The headway should not be less than 9 feet, and the floor of floating bridge should ordinarily be not less than $2\frac{1}{2}$ feet above the water-line.

Ramps at the end of a bridge if intended for artillery should not have a slope steeper than one-seventh, but slopes greater than one-tenth are inconvenient, more especially for animals.

*Loads on Military Bridges.*

The following are the principal loads that can be brought on a bridge by the passage of troops of various kinds, guns, &c.:—

Infantry in marching order, average weight 200 lbs. per man, cause, when crowded, a load of $1\frac{1}{4}$ cwt. per lineal foot of roadway.

Infantry in marching order, in file, crowded, cause a load of about $2\frac{1}{2}$ cwt. per lineal foot of roadway.

Infantry in marching order in fours crowded, cause a load of 5 cwt. per lineal foot of roadway.

Infantry in marching order, when crowded in a disorganised mass, may cause a load of 100 lbs. per *square* foot of standing room, and unarmed men, average weight 160 lbs. per man, may, when crowded in a disorganised mass, cause a load of 133 lbs. per *square* foot of standing room; this, in a bridge 8 feet wide, would be about 9 cwt. per foot lineal of roadway.

Cavalry in marching order, in file, each man and horse together weighing about 1,400 lbs., and occupying 12 feet lineal of bridge, cause a load of about 1 cwt. per lineal foot of roadway.

Cavalry in marching order, in file, crowded, cause a load of less than $1\frac{3}{4}$ cwt. per lineal foot of roadway.

Cavalry in marching order, in half sections, crowded, cause a load of nearly $3\frac{1}{2}$ cwt. per lineal foot of roadway.

The following table gives the weight of field guns, &c., fully loaded for travelling:—

| Description of gun, &c. | Weight upon fore and hind wheels respectively. Fore, or limber. cwt. | qrs. | Hind, or gun. cwt. | qrs. |
|---|---|---|---|---|
| 16-pr. M.L.R. gun (iron) | 16 | 2 | 25 | 2 |
| 9-pr. " " " of 8 cwt. | 12 | 0 | 19 | 2 |
| 16-pr. ammunition wagon | 17 | 0 | 23 | 3 |
| Pontoon wagon | 15 | 0 | 24 | 0 |
| Wire wagon | 15 | 3 | 22 | 3 |
| General Service wagon with springs, heavy | 28 | 1 | 34 | 4 |
| General Service wagon with springs, light | 18 | 3 | 26 | 3 |
| Small arm ammunition cart | — | | 19 | 0 |

For calculations of strength and buoyancy, the following classification of bridges may be found convenient.

1. Foot bridges for infantry in single file; breadth of roadway up to 3 feet; maximum load per lineal foot of roadway about $1\frac{1}{4}$ cwt.

2. Infantry bridges for infantry marching two abreast; these bridges would usually be available for cavalry in single file, leading their horses and light guns passed over by hand. Breadth of roadway, 6 feet; load per lineal foot $2\frac{1}{2}$ cwt.

3. Advanced bridge equipments available for a field force of infantry in fours, cavalry in half sections and field artillery; breadth of roadway, not less than 8 feet. Load about 5 cwt. per foot run.

4. Heavy bridges adapted to the passage of siege artillery. These usually require to have special arrangements made for strengthening the roadway and supports.

It should be noted that the greatest weight which the pier of a bridge is likely to sustain during the march of an Army, is caused by crowded infantry, and that the weight of crowded cavalry may be greater than that of artillery. It is necessary to bear this in mind—because during the passage of the Elbe at Priestnitz, in 1813, the Officer in command of the cavalry, thinking that because the artillery had passed there was no reason to question the security of the bridge for cavalry, let his files close up, and afterwards trot, the result was, that the bridge broke down.

## *Sites for Bridges.*

In choosing a site for a bridge across a river, the chief points to be recollected are:—

1st. The site should be as near as possible to the main communications.

2nd. The position most easily defended is a re-entering bend, where the bridge may be secure from fire, and the ground in front exposed to a cross fire from the near bank.

3rd. The bridge should, if possible, start under cover of a commanding bank, woods, or undulations, while the opposite bank should be open.

4th. Banks or marshes which make the approaches to the bridge difficult, or portions of the stream with very strong currents or shoal-water, should be avoided.

5th. In tidal rivers, banks steeper than $\frac{1}{7}$th, or beds likely to injure the piers when grounded, should be avoided.

6th. In attempting the passage of a river in face of an enemy, every practicable ruse should be devised to conceal the point at which the passage is to be made.

7th. The first operation should be undertaken with detached means, such as row-boats, rafts, and flying bridges prepared beforehand, and concealed until the passage is to be attempted.

A *flying bridge* is one in which the action of the current is made to move a boat or a raft across the stream, by acting obliquely against its side.

I have already stated that military bridges are of two classes, viz.:—

I. Floating, } bridges.
II. Fixed }

These may again be considered under two heads:—

1st. Those formed of bridge-equipments prepared to accompany an army.

2nd. Those improvised out of such material as can be locally procured.

In designing a permanent bridge, solidity, durability, and economy are the chief points the engineer has to consider; but a condition under which military bridges have in nearly all cases to be formed, is *rapidity of construction*, and consequently the necessity for this has to be kept in view in all typical forms of bridges proposed for the equipment of an army, or for the instruction and practice of troops.

Another condition which, though not common to all cases, is in many even of more importance than the first, is *portability*.

Subject to these conditions, there is little difference between the kind of technical knowledge required in a military as compared with a civilian bridge-constructor; but it will be manifest that experience in the direction of skilled labour, and practice in turning local resources to the best account, are desirable, if not necessary, qualifications in a military bridge-constructor.

### *Improvised Field Bridges.*

The types of improvised bridges constructed in carrying out the courses of bridging laid down for our troops are of the two kinds already mentioned—

I. Floating bridges.

II. Bridges with fixed supports.

The fixed bridges are of four kinds, namely:—

1st. Trestle and pile bridges, applicable to rivers or gaps where the bottom is available for supports.

2nd. Frame bridges used for clear spans up to 60 or 70 feet.

3rd. Tension bridges used for clear spans up to 100 feet.

4th. Suspension bridges, which may be used for still larger spans.

For improvised fixed bridges, timber (often green and in the rough) is the material most frequently available.

The ordinary fastenings are rope lashings, wooden trenails, and iron bolts and nuts, nails, spikes, and dogs.

For instructional purposes, round spars and rope lashings, materials which admit of being used repeatedly, are generally employed, hence the term "spar-bridging;" but it should be clearly understood that the principles which regulate the construction of spar-bridges equally apply to structures in which timber of any other form, and other kinds of fastenings than rope are used. Iron fastenings are, of course, better suited than rope for semi-permanent bridges, and for those made of material not required for re-use.

Before troops are employed at bridging, they should be thoroughly instructed in the various knots and splices used in lashing spars together. The knots and lashings, a knowledge of which is essential for spar-bridging, are few in number, they are easily learnt, and if not practised, are easily forgotten.[1]

### *Trestle Bridges.*

Trestles are most useful in establishing communications across shallow rivers, having sound and hard beds, and which are not subject to sudden floods; for crossing ravines (up to 30 or 40 feet deep), where the bottom is available for support; and for crossing roads in use.

They can be readily constructed of any kind of timber, and are easily placed in shallow water, but are not so suitable for deep muddy rivers. Light rails and sleepers have been used for making trestles.

Single frame trestles may be used in streams 6 feet deep, and running with a velocity of 5 feet per second (equal to $3\frac{1}{2}$ miles an hour), or in deeper streams if the velocity of the current be less. They are suitable for any kind of tolerably firm bottom.

Tripod trestles may be used in water up to 6 feet deep, with a velocity of 5 feet per second, and in streams with muddy beds. Their great advantage is, that if the water rise, or one tripod sink into the mud more than the other, the level of the roadway can be readily adjusted.

When timber is plentiful, it has sometimes been found best to build solid piers of crib work, weighted inside with stones, &c., instead of using trestles. The piers of the bridge across the Prah were of this nature.

### *Pile Bridges.*

When the legs of the trestles or supports are driven into the ground, they are termed pile bridges.

The bridge across the Ordah was of this type.

It was made under the following conditions:—

The river Ordah, about 10 miles from Coomassie, was reached by the European force on the afternoon of the 3rd February.

The river was 80 feet wide and 3 to 4 feet deep, and the construction of the bridge was at once commenced, and with a short rest, continued throughout the night and was completed at 5 A.M. No material or fastenings of any kind except what grew on the banks were available; the only tools were axes.

On the return march on February 6th, the heavy rains had swollen the river, which rose 18 inches above the roadway. The bridge was damaged, but its reconstruction would have taken some hours, which could not be spared for the purpose. The force, except the rear-guard, including all baggage and stores, were, however, able to get over the bridge.

As night was coming on and the river was rising rapidly, the rear-guard forded the stream, the water being up to the men's shoulders, natives who could swim, taking over the arms and clothes.

[1] For technical details of Military Bridge Construction, see vol. i (Part III) Instruction in Military Engineering." Edition, 1875.

### *Frame Bridges.*

Frame bridges are used to provide intermediate points of support where piers resting on the ground or floating piers are not available. The length of the intervals between the supports depends on the strength of the available road-bearers, while the width of the opening and the depth of the footings below the surface, decide the form of the bridge.

The forms commonly used are:—*Single* and *double lock* bridges, which provide one and two points of support respectively, and *sling* bridges, which provide a larger number.

Types of these bridges are given in Plates XXXIII. to XXXVII.

### *Single-Lock Bridges.*

The single-lock bridge (formerly called single lever) is not suitable for greater spans than about 30 feet; it is composed of two frames locking into each other, as shown in Plate XXXIII.; these frames should not slope more than two-sevenths. The bridge can be erected by a party of two Non-commissioned Officers and 20 men, half on each side of the stream or chasm, in two hours, provided proper stores are available and in position on either side of the stream.

### *Double-Lock Bridge.*

The double-lock bridge (formerly called double lever) is suitable for spans of 40 feet, and consists of two frames locking into a connecting frame of two or more distance-pieces with cross transoms as shown in Plate XXXIV.; the opening is thus divided into three spaces, and the span of the road-bearers is about 14 feet. The bridge can be constructed by a party of three Non-commissioned Officers and from 24 to 48 men, and be completed in three to four hours.

### *Single Sling Bridge.*

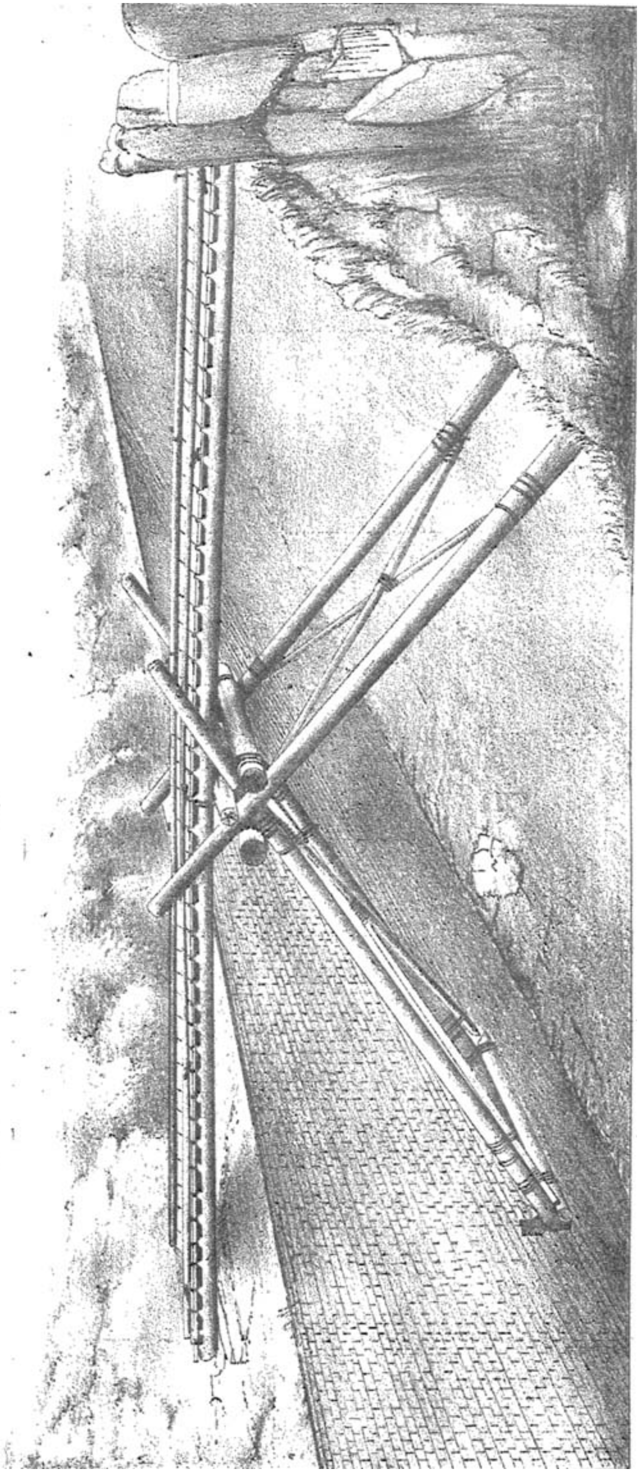
The single sling bridge (formerly called the single truss) can be used for spans up to 50 feet; it consists of two frames locking into each other in the same manner as in the single-lock bridge, and provides three points of support, viz., one on each frame (a) and (b), and a third (c) suspended by slings from the heads of the frames (Plate XXXV). The bridge requires a party of three Non-commissioned Officers and from 30 to 48 men. The operation of getting the frames into position will require about four hours, and the roadway can be laid and bridge completed in about six hours.

For either of the foregoing bridges extra time should be allowed if the footings have to be cut in masonry or brickwork, as would be necessary in restoring a broken arch, or if trestles had to be formed as at (d) Plate XXXV.

### *Stiffened Single Sling Bridge.*

The single sling bridge may be adapted to spans up to 60 feet by the arrangement shown in Plate XXXVI.

PL. XXXIII.

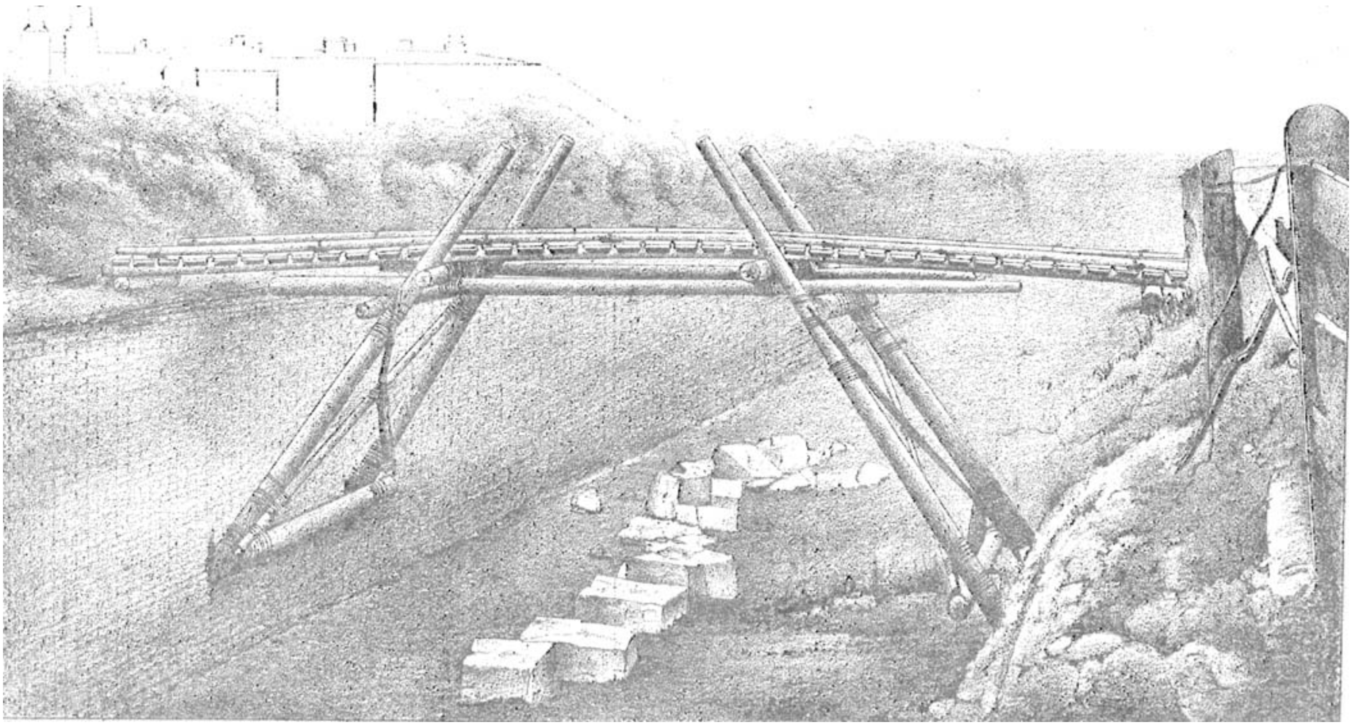


SINGLE LOCK BRIDGE.

School of Military Engineering, Chatham.

Journal R.U.S. Institution.
Vol.19.

PL.XXXIV.



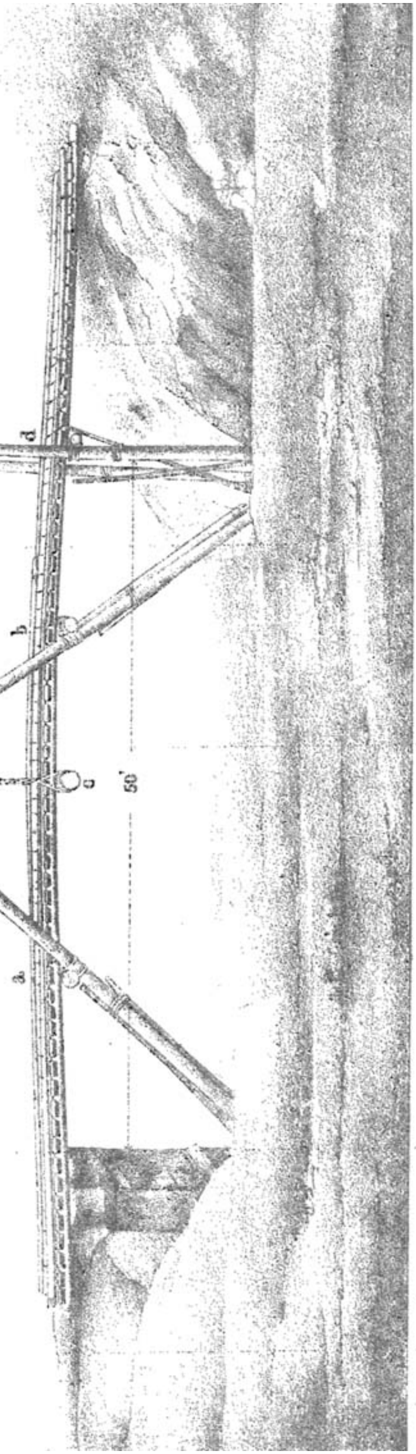
School of Military Engineering, Chatham.

DOUBLE LOCK BRIDGE.

Journal R.U.S. Institution
Vol 19.

PL. XXXV.



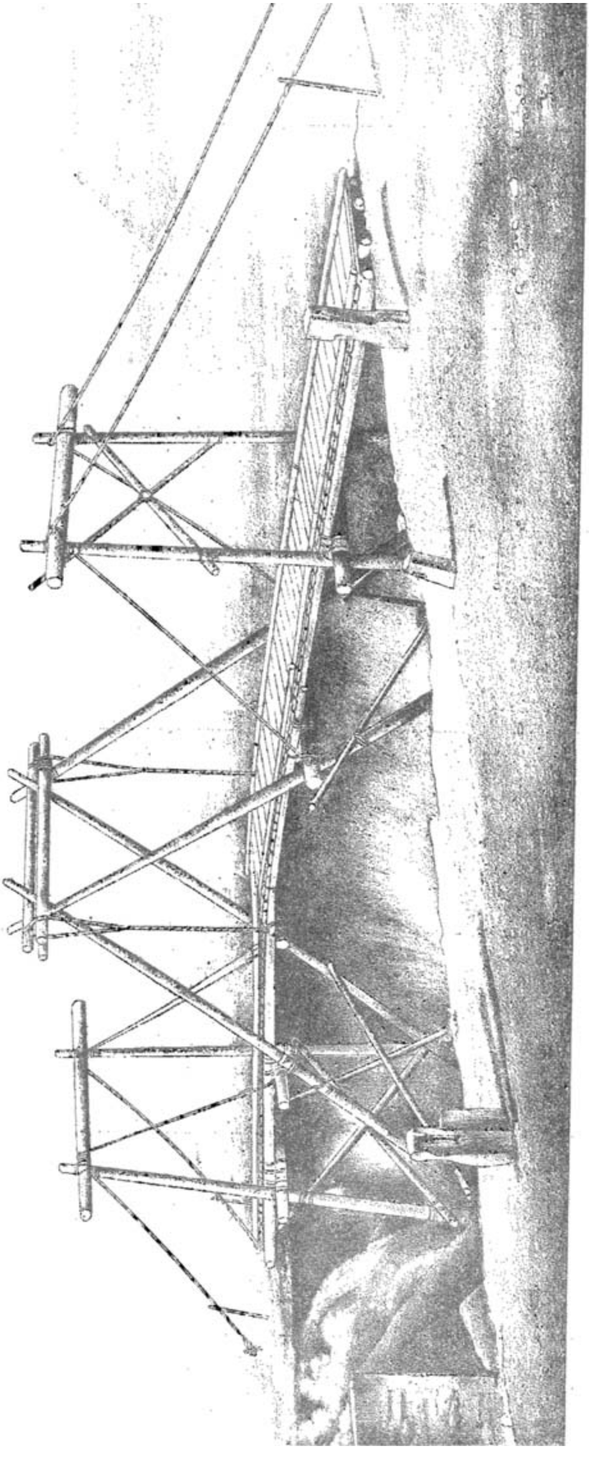



SINGLE SLING BRIDGE.

School of Military Engineering, Chatham.

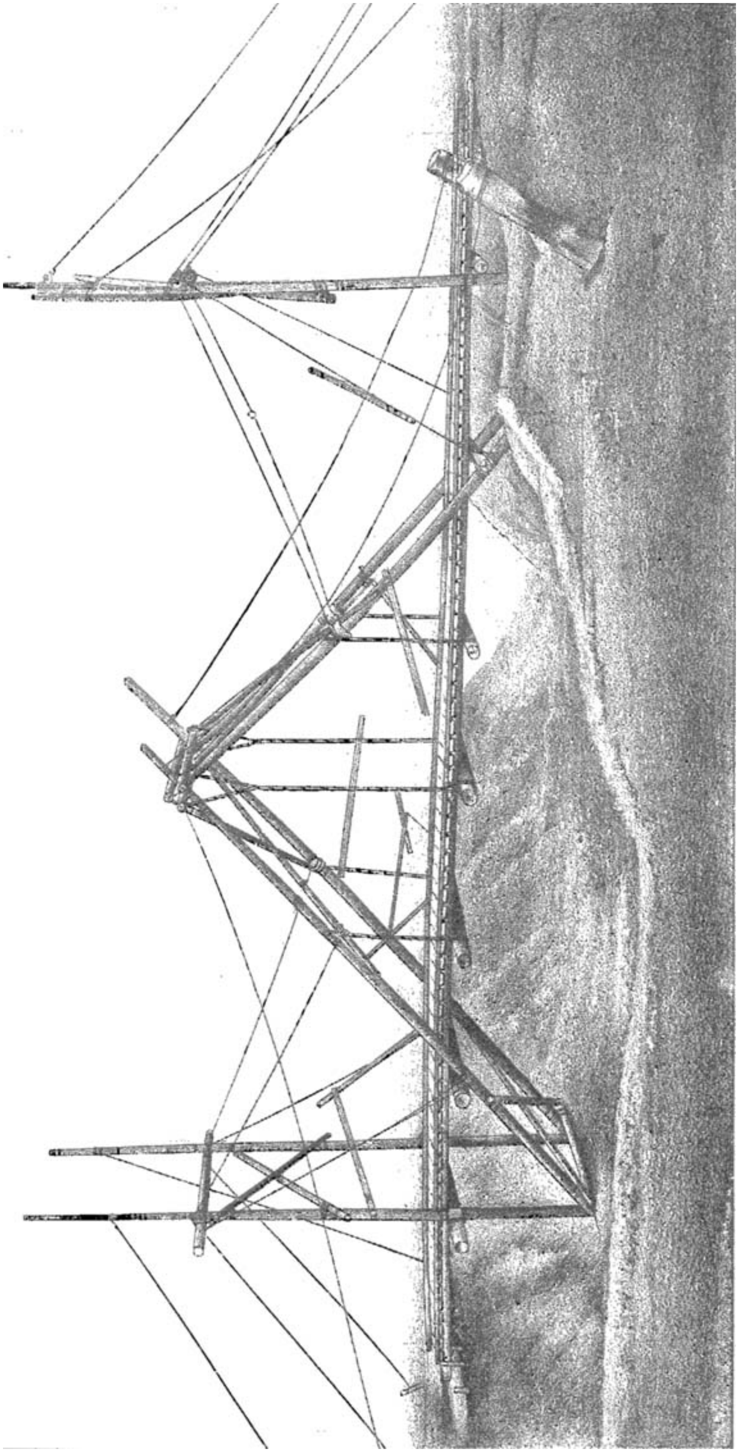
Journal R.U.S. Institution.
Vol. 19

PL. XXXVI



STIFFENED SINGLE SLING BRIDGE

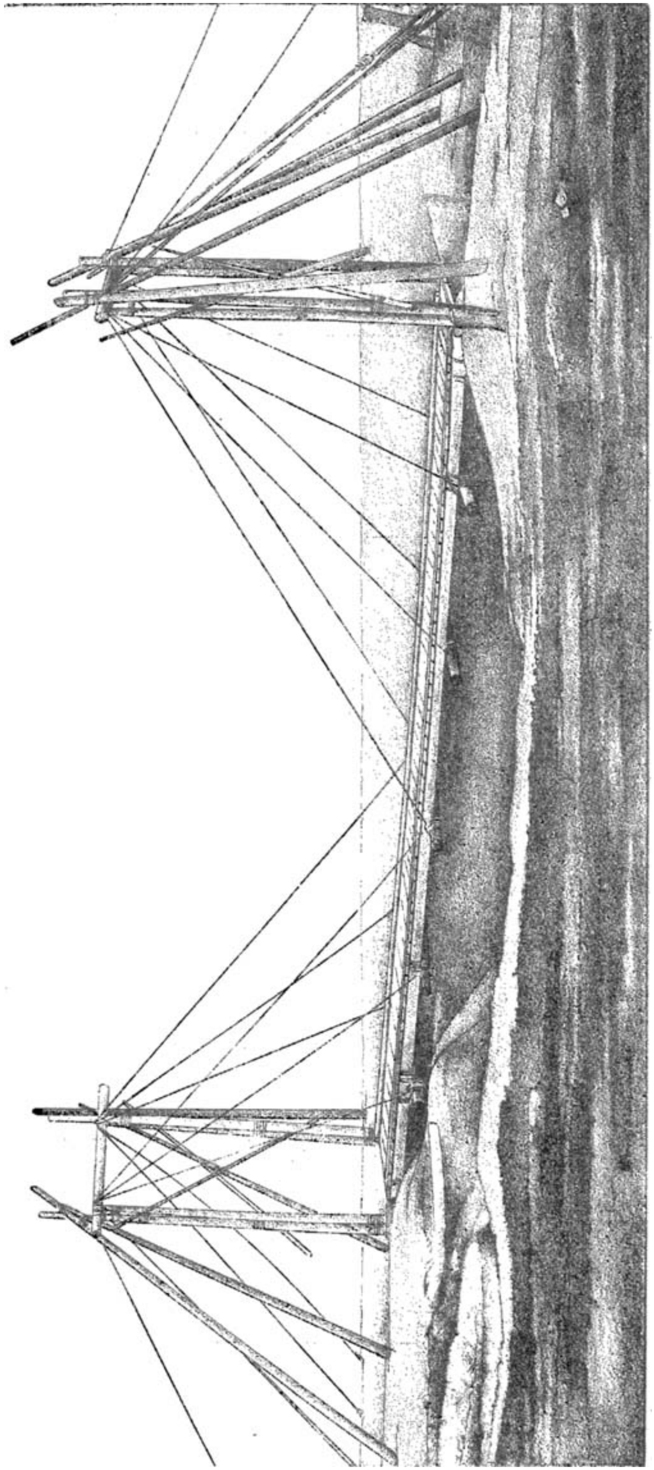
School of Military Engineering, Chatham.



TREBLE SLING BRIDGE.

School of Military Engineering, Chatham.

PL. XXXVIII.

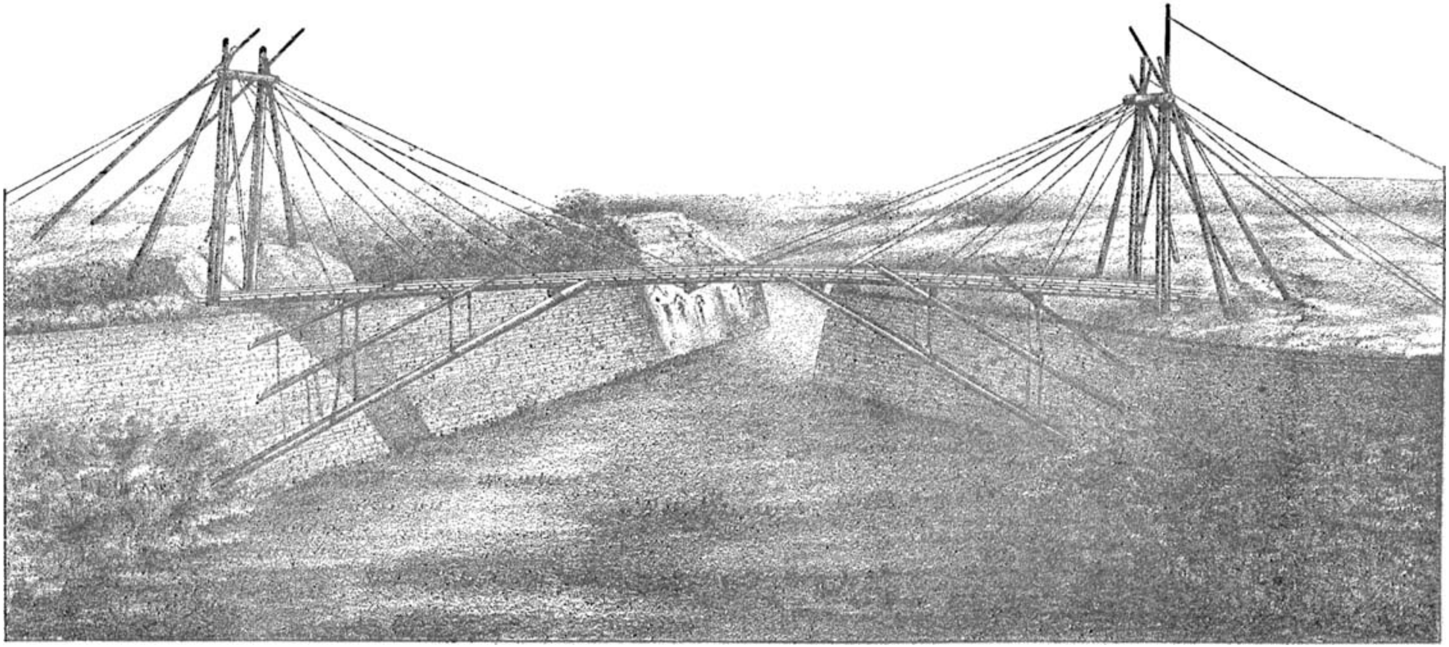


TENSION BRIDGE.

School of Military Engineering, Chatham.

Journal R.U.S. Institution.
Vol. 19.

PL. XXXIX



School of Military Engineering, Chatham.

STRUTTED TENSION BRIDGE.

A bridge of this form (span between points of support 60 feet) was constructed so as to carry a 40-pounder B.L.R. gun (63 cwt. on hind wheels), and over 40 men $5\frac{3}{4}$ hours after it was commenced, the standards being yard-arms, two of them only 5 inches at the butts, the ties of hemp—(3 in.)—rope.[1]

*Treble Sling Bridge.*

The treble sling bridge stiffened by ties as shown in Plate XXXVII., is one of the strongest that can be made with spars and lashings, and may be used for spans up to 70 feet. This bridge only differs from the last in having each standard tied at two points instead of one, which allows the span to be divided into six parts.

A party of three Non-commissioned Officers and 36 to 48 men should make this bridge in six to ten hours if the materials were all at hand.

*Tension Bridges.*

When the span exceeds 60 or 70 feet, or when the standards required for frame bridges cannot be procured, tension bridges (examples of which are given in Plates XXXVIII. and XXXIX.), may be found suitable.

The advantages of these bridges are:—

1st. They are suitable for larger spans.

2nd. The ties are more easily transported than timber.

3rd. The roadway is as rigid as that of a spar bridge.

They take, however, longer to make than trestle bridges, and except with very strong materials, are only suitable for narrow roadways arranged to suit the track of the carriages which have to pass.

The strutted tension bridge (Plate XXXIX.) was constructed across a clear span of 100 feet, but is equally suitable for smaller spans.

*Suspension Bridges.*

In suspension bridging there are three convenient ways of using the suspension cables as supports for the roadway.

The first and most usual method is to hang the roadway below the cable.

The second is to lay the roadway partly on the cables and partly on baulks.

The third is to support a horizontal roadway on trestles carried by the cable.

The first provides a road fit for all kinds of traffic, but requires more materials than the others.

The second plan is the simplest, and requires least materials; it answers for troops and light guns.

The third provides a very stiff bridge, and saves having high piers, but is more influenced by wind, and is unfit for crossing water with banks lower than the heights of the trestles.

[1] This bridge was constructed by a class of Officers of the Guards, cavalry, and line, and some Royal Engineer recruits, under the direction of Captain T. Fraser, R.E. (Assistant Instructor in Field Fortification), by whom many of the details of the bridges described, have been worked out.

The site for a suspension bridge should be chosen with banks of the same height, and of sound rock or clay.

The best materials for cables are iron chains, steel or iron-wire ropes; hemp ropes, iron gabion bands, sail cloth, thongs of hide, and ropes of creepers or grass, or even small baulks pinned, or boards nailed together, are sometimes employed.

The roadway of a suspension bridge ought not as a rule to be wider than is necessary to allow of the passage of the vehicles it is to carry.

In India, suspension bridges for foot passengers are made of one or two cables, with hand-rails of rope or bamboo.

### *Floating Bridges.*

Floating bridges afford a continuous roadway, supported on *piers* of boats, casks, or rafts. The piers are connected by beams, usually called *baulks*, on which a roadway of planks, usually called *chesses*, are laid.

Pontoon is the name given to a portable floating pier specially prepared for military bridges.

In floating bridges, each pier must have enough available buoyancy to support the heaviest load that can come over it. The piers should be at as wide intervals as their buoyancy and the strength of the baulks will permit.

The supports of a floating bridge should be at least twice as long as the width of the roadway, unless the buoyancy is much in excess of that required.

If it be not possible to make the bridge strong or wide enough to carry the different arms when crowded, notices should be put up at the bridge, stating what loads may safely cross.

Straw laid on the planks of a bridge deadens the noise for horses and prevents slipping.

In cases where there is a large tidal variation, the arrangement of bridge-ends, to be at all times available, is a work that requires much time, materials, and labour, and may be impracticable for hasty operations.

Cuts are sometimes wanted in floating bridges to allow traffic to pass, or to permit large floating objects, such as trees or ice, to be towed or guided through the bridge.

Boats or coasting vessels, &c., being frequently required in military operations for making bridges, it is necessary to be able to determine their flotation.

On rivers, boats are often of a nearly uniform section; this section multiplied by their length will give the cubic contents, and the cubic contents in feet, multiplied by $62\frac{1}{2}$, will give the weight of water displaced in lbs., and the consequent buoyancy.

With small boats, the easiest way is to load them with unarmed men to such a depth as is considered safe for bridging, then multiply the number of men by 160, and the result is the available buoyancy in lbs.

A rough rule for the proper interval between boats in bridge is to divide the number of men they safely hold by 4, and the result is the number of feet the boats may be apart from centre to centre. Thus, boats holding 60 men might be at 15 feet central intervals.

A simple practical rule for finding the buoyancy of a cask is to multiply the number of gallons it contains by 10, which gives a result in lbs. a little less than the actual buoyancy.

The buoyancy of timber, &c., for rafts will be found by calculating its cubic contents and deducting the weight of the material from that of the water displaced.

Anchors are required to counteract the effect of the current or wind on floating objects; the nature of holding ground, and the strain on the cables, regulate their size. To ensure holding, the length of the cables should be 10 times the depth of the stream, and in no case less than 30 yards. When the length is less than three times the depth, the anchors seldom hold.

An improvised anchor may be made of pickaxes lashed together, of bent iron bars, or of wicker cases filled with stones.

*Portable Bridge Equipments.*

The portable bridge-equipment, which forms part of the *matériel* requisite for every field force, usually comprises two forms of bridge-construction capable of being used either separately or in combination, viz., pontoon bridges and trestle bridges; the first forming a floating and the second a fixed bridge.

Complete bridges can only be constructed of pontoons alone across channels, when there is water at either bank, sufficient at all times to float the pontoons, a condition not usually obtainable in waters subject to rise and fall of tide, or to sudden changes of depth, due to floods from falls of rain, &c.

It follows, therefore, that even for crossing rivers, the bridge-equipment can rarely be confined to pontoons, and there are, of course, cases where the military communications may have to be rapidly completed over gaps where a pontoon cannot be used at all. An equipment of fixed supports (usually trestles) is in such a case a necessity.

As the pontoon and trestle equipment, which accompany the advance of an army, are usually required to be moved along with the divisions to which they are attached, they have frequently to be replaced by other non-portable bridges made out of such material as can be most conveniently procured.

In such cases, rapidity of construction, with a view to set free the portable equipment, and fertility of resource in turning to the best account the materials at hand, should mark the military bridge-constructor.

To give effect successfully to these requirements, the directing officer should be thoroughly trained to bridge-construction. He should endeavour, by a proper distribution of men and material, rapidly to construct his bridge of the required strength; questions of appearance, economy of material, and permanency being of secondary consideration.

In the Journal of this Institution,[1] will be found carefully prepared papers, giving detailed particulars of the pontoons and trestles used in the bridge-equipments of the chief continental armies, and those which were in use in the British Service up to the year 1870. In these papers, the merits and demerits of the pontoons described, are minutely entered into. The subject was then of considerable interest, as a change in the nature of our own bridge-equipment was deemed necessary, and there was naturally much discussion as to what the new pattern should be.

After much consideration and practical trial, the pontoon (Plate XL.) was adopted for the British Service.

Attention is also directed to the German pontoon (Plate XLI.), which has, of all foreign models, been that most largely and successfully used in late wars.

*Pontoons.*

A pontoon should fulfil the following conditions:—

1. It should be capable of sustaining the greatest load liable to come over it while in bridge.

2. It should be as portable and light as consistent with the first condition, and with the capability of standing the rough usage to which it would be subject on active service.

3. The pontoon, with its corresponding superstructure, should be of such a form as to admit convenient stowage in wagons, and of being easily converted into a bridge, and of being rapidly moved with the advance of an army.

4. It should be of a form and material that admit of a ready examination and of being easily repaired, and it should not be liable to damage or leakage from alternate exposure to wet and heat.

5. Wagon loads should be complete in themselves, and the parts of the equipment should be interchangeable.

6. The pontoon should be capable of being used as a boat.

*Austria.*

The Austrian pontoon and trestle equipment is fully described by Colonel Lovell in vol. ix, pages 42—46 of the Journal of this Institution.

The pontoons are formed in sections, and in making bridges, two, three, or four of these sections are used according to the degree of buoyancy required in the supports. Supports made of two sections are supposed to meet ordinary requirements.

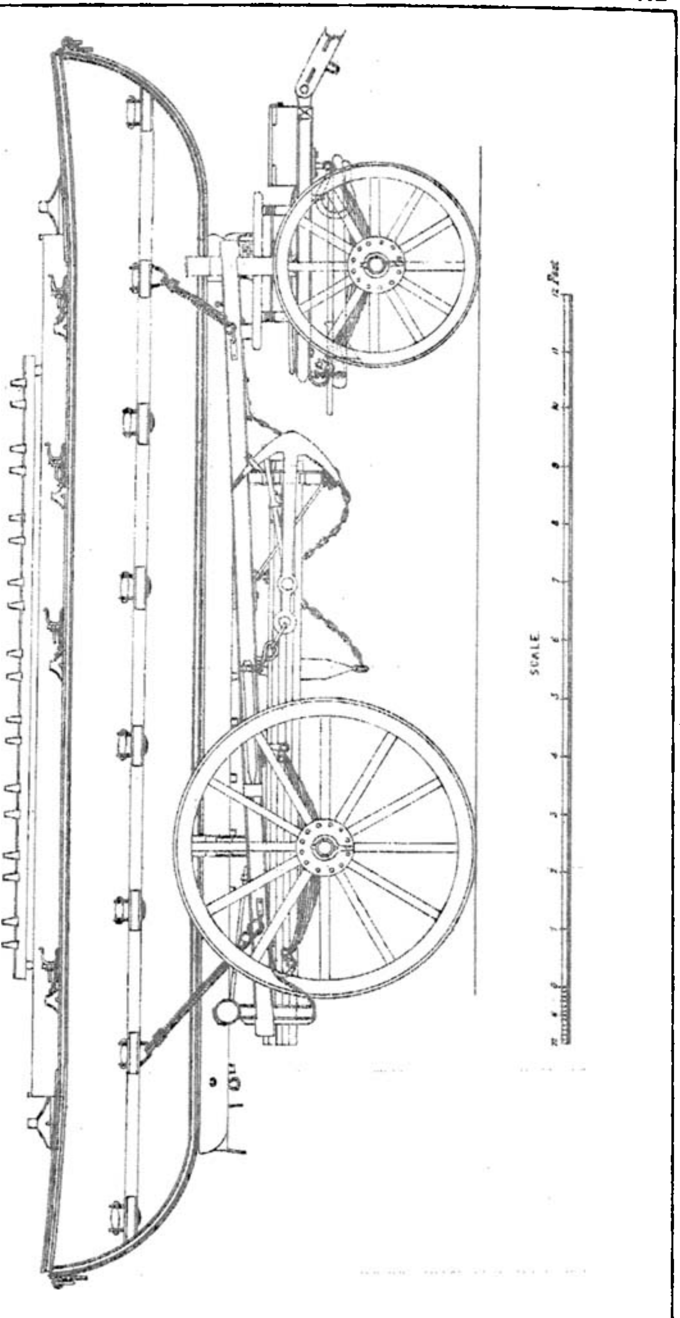
Single sections may be used for narrow infantry foot bridges. Owing to the size of the pontoons, and the distance at which they are placed apart, some of the superstructure of the equipment is clumsy and not easily handled.

The trestles used in the Austrian pontoon equipment (see Plate IX., page 44, vol. ix), are two-legged, usually called "Birago trestles" (after General Birago, by whom the Austrian equipment was devised), and are of the kind most largely used in the bridge-equipments pre-

[1] Vol. iv., pp. 237, et seq; and vol. ix., pp. 29, et seq.

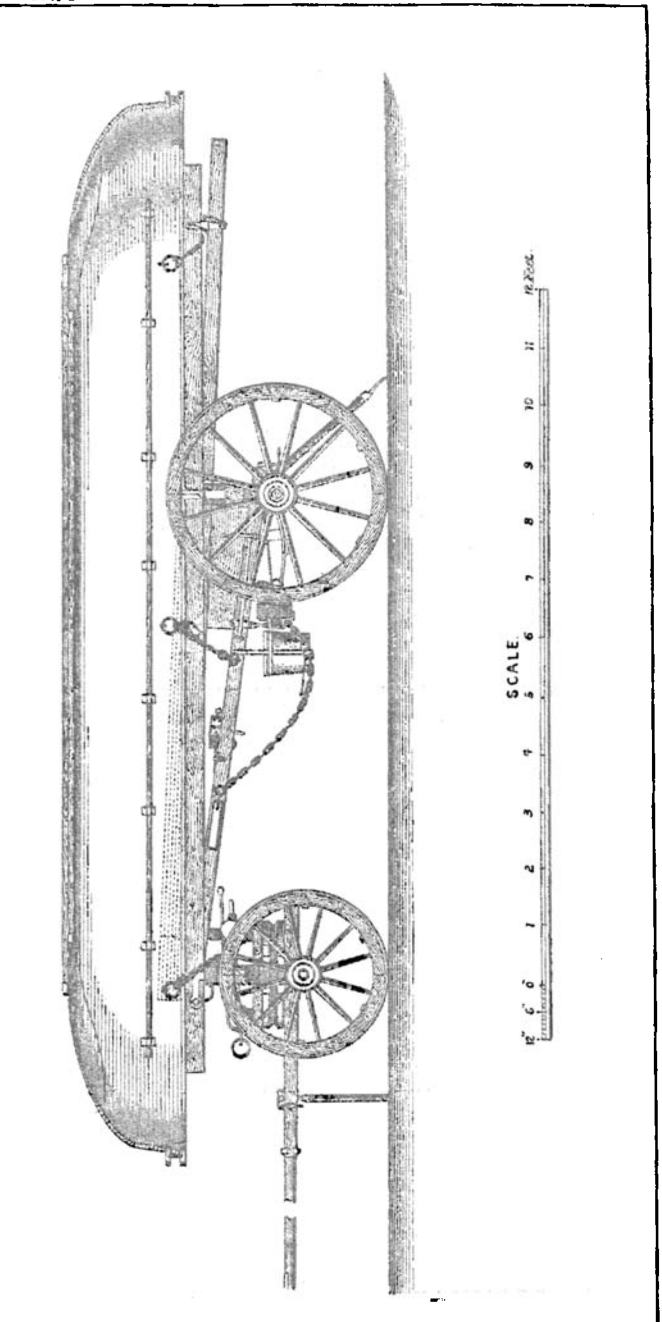
PL.XL

BRITISH PONTOON LOADED ON WAGON.




Papyrotype. S.M.E.

GERMAN PONTOON LOADED ON WAGON



pared to accompany Army Corps. They are easy of transport, and when the bed of the river is fairly solid, and the depth and current of the water not great, they make a good bridge for field troops. Their stability, not at any time as great as could be desired, depends on the cleated baulks which connect them with the shore.

Each trestle is provided with three sets of legs to suit various depths of water.

Their great disadvantage is, that if, on account of alteration in the depth of water due to rise and fall of tide, or other causes, it becomes necessary to alter the level of the bridge in deep water, this cannot always be done without stopping all traffic, and without considerable subsequent delay in re-adjusting the heights of the cross-pieces (transoms) which support the roadway.

A section of the bridge-train consists of 14 wagons, each carrying part of a pontoon, and provides supports and superstructure for 168 feet of bridge. There are 40 such sections = 6,720 feet = 2,900 yards of bridge, and 8 more in reserve.

During the year 1873, pontooning operations took place near Linz, at which point the River Danube is about 280 yards wide, and the current very rapid, in some cases as much as five miles an hour.

The number of men employed to construct a bridge varied, and amounted to from 300 to 400 men, including Non-commissioned Officers. The time occupied was from 3 to $1\frac{1}{2}$ hours, the minimum time being when the work was done in the presence of the Emperor.

Openings were made in the bridge to admit of the passage of steamers, &c., the average time taken to make the opening was about 10 minutes, and to close it 14 minutes.

By night the bridge was put together in $2\frac{1}{2}$ hours, about one-half the length having been formed by day and brought into position by night.

Large numbers of troops were, during the operations, ferried across the river in pontoons.

## *Belgium.*

The Belgians have a pontoon-train-equipment for about 260 yards of bridge.

The pontoon and trestle-equipment are very fully described by Colonel Lovell, pages 49, 50, vol. ix.

The trestles are three-legged, and of a construction which admits of the adjustment of the legs to suit uneven ground. Their great advantages are, stability and facility for altering the level of the bridge during rise and fall of tide. They are more difficult to place in deep water than two-legged trestles, but when placed, they are safer.

The shape of the pontoons has been worked out with great care, and they possess, in a high degree, many of the elements of a good pontoon.

Their weight, 1,200 lbs., is, however, greater than appears admissible for a train which is to keep up when necessary with the advance of an Army.

*France.*

The French Bridge-Equipment, as approved in 1853, and still used, comprises 4 divisions and 1 reserve. The equipment is composed of open wooden boat pontoons, light boats, and trestles (2 legged). The proportion in each division of pontoon-train consists of 8 pontoons, 2 trestles and 1 light boat.

This is sufficient for 58 yards of bridge without using the trestles, and 70 yards using the trestles.

The complete equipage is sufficient for about 215 yards of bridge without using trestles, and 265 yards if trestles are used.

The French pontoon train was largely used in the campaign of 1859; and after the experience of that campaign, it was stated that the regulation bridge-equipment, while well adapted as a reserve for the passage of large rivers, did not possess the mobility necessary to enable it to follow the movements of the Army divisions, or to render all the services expected of it in a country intersected by numerous watercourses of medium size.

A lighter equipment has been under trial, but I learn that it has not yet been adopted.

*Holland.*

The Dutch pontoon train consists of 2 companies and a depôt. One company is organized to accompany a field force, and consists of 3 officers, 21 non-commissioned officers, and 175 men.

The pontoon is an open flat-bottomed wooden boat, with flat sloping ends. Length, 26 feet. Weight about 1,250 lbs.

It is, like the French pontoon, too heavy to be carried on the same wagon with its superstructure, and the introduction of an improved pattern is contemplated.

The number of pontoons (30) is sufficient for 220 yards of bridge.

The trestles used are of the Belgian pattern. Eight are carried, sufficient for 28 yards of bridge.

Total bridge train, nearly 250 yards.

Pontooning operations take place annually at Dordrecht, where the river is about 150 yards wide, the rise and fall of tide being about 4½ feet.

The Dutch Army being a militia force, the time allowed for training their pontooneers is very short.

*Russia.*

The Russian bridge-trains are composed of half a battalion (two companies) of pontooneers to each Army Corps. Each company consists of 200 non-commissioned officers and men including 60 drivers. Each half battalion has 26 iron pontoons in two compartments (carried on 52 waggons) and 12 trestles, and the equipment is sufficient to form a bridge 260 yards in length.

The Russian pontoon is in form and size very similar to the Austrian, and the superstructure is of the same kind.

The trestles also resemble the Austrian bridge pattern.

*Germany.*

The new pattern German pontoons are of iron; an old pattern of the same shape is of wood, and is now used for reserve equipments. The pontoon has similar boat-shaped ends, is not decked, and the material not being buoyant, it is liable to sink in case of accidental damage. (Plate XLI.)

Its weight is about 950 lbs., and its available buoyancy is from 9,000 lbs. to 10,000 lbs.

Used singly, the pontoons do not make safe boats for a number of men, but whether used as boats, or in bridge, they offer, from their shape, less resistance to wind and current than pontoons with square ends.

The pontoons, as well as the superstructure, are of simple form, they can be placed in bridge at any desired interval apart, and are readily adapted to the varied conditions under which a portable bridge-equipment may have to be used.

Since the last war, the arrangements for the manning and equipment of the German Pontoon Corps have been modified, and the system previously in force of having only the company for each army corps trained as pontooneers, has been abandoned.

Every company of the engineer force liable to take the field, is now trained to undertake bridging operations, and in place of heavy and light bridge-trains, all bridge-trains are alike, and capable of being used together.

Under the Regulations, date 1874, now in force, each army division has a divisional bridge-equipment, composed of 6 pontoons and 4 trestles, sufficient for 43 yards of bridge, and each army corps has in addition a corps equipment of 24 pontoons and 2 trestles sufficient for 146 yards of bridge. Total for each army corps, 232 yards of bridge.

This equipment is always in charge of the officers and companies told off to move with it on service in the field, and they use it (when required) for their annual practice, and keep it in repair.

In addition to this equipment which appertains to the army corps, there is a certain small amount of bridge material allowed for instructional practice; there are also, in charge of the engineer troops quartered in the fortresses on important rivers, such as the Rhine and Elbe, reserve equipments for service in those rivers, the amount being what is considered sufficient for any special bridge likely to be required.

It will thus be seen that, as the result of their experience during the late war, the Germans have increased their cadres of bridge-constructors, and simplified their equipment with a view to obtaining greater bridging resources.

In addition to the regular bridging-exercises of the German engineer troops, whose head-quarters are always fixed at some fortress on a river so that they may have constant practice in bridge-construction, pontooning operations on a large scale take place periodically on one of their more important rivers.

Last year these operations took place on the Southern Elbe at Harburg, and a short account of them may be of some interest.

The operations were carried out between July 20th and August 15th, 1874, in accordance with a programme which had been prepared some months beforehand, and a sum of money was placed at the disposal of the Directing Officer (Colonel Crüger), to defray all attendant expenses.

The troops taking part in them were 2 companies of pioneers from each of 4 Army Corps (Guards, 4th, 9th, 10th), and one company from the 3rd Army Corps. Total 27 officers and about 800 non-commissioned officers and men.

A Captain or senior Lieutenant from every pioneer battalion not represented by companies, was also ordered to attend the operations.

The Elbe, at the point selected for the practice, was from 370 to 400 yards wide.

The material used in making the bridges was the bridge-equipment of the 3rd, 4th, and 9th Army Corps, the Elbe Reserve, and the instructional *matériel* of the 4th and 9th Pioneer battalions.

This was sufficient to enable two bridges, total length about 750 yards, to be constructed daily at two separate bridging grounds about 1,200 yards apart.

The exercises were carried out for five days in each week, and various modes of constructing bridges were practised, both by day and night.

On each occasion, bridges complete in all respects were formed, and cuts for the passage of boats and barges were opened and closed.

The work was essentially practical and instructive.

Among the more noticeable operations were :—

The construction of a bridge 370 yards long, in a very dark night in less than two hours. The work was carried out so quietly that noise could not be heard a few hundred yards off.

On another occasion, the programme was to convey the materials in rafts some three miles down the river, and to form a bridge at a site indicated.

The spot selected was near Sandau.

The river here has a breadth of 400 yards, and a smaller arm had also to be bridged over in order to complete the communication, its breadth being 140 yards.

It was ordered that the material should be formed into rafts of four pontoons, and be brought up on the morning of the 6th, so as to reach the bridging ground at 7 A.M. In order to do this, some of the men had to leave their cantonments soon after 3 A.M. The rafts left the bridging ground at Harburg at 5 A.M., and at the appointed time, the bridge was commenced by placing some trestles.

During the forenoon the wind rose and blew a gale and the tide rose abnormally. It was, in consequence, found necessary to raise the trestles, which was a difficult operation and took some hours. The rafts could not be brought into their position in bridge against the tide and wind by rowing, and had to be warped up one by one. This caused further delay, and it was 3.30 P.M. before the bridge was completed during a storm of wind and rain of great violence.

After a rest of less than an hour, the bridge was dismantled, but owing to a further rise in the level of the river, and consequent overflowing of the river banks, there was a delay in securing the material, and it was 11 P.M. before some of the men got back to their cantonments.

The next morning they were at work at the usual hour, 6 A.M.

The battalion of infantry quartered at Harburg, was, on another occasion, conveyed across the river in small transport rafts, in the presence of His Excellency Lieutenant-General von Treskow, commanding the 9th Army Corps.

To conclude the operations, the bridge-material was formed into large transport rafts, consisting in one case of as many as 48 boats, which were towed by steamers and formed into bridges (one over 500 yards long), at different points on the Elbe, the troops going into bivouac on the river banks.

These final operations were performed in the presence of three Inspecting Generals of Engineers who came from Berlin for the purpose.

I was much struck with the quiet demeanour and the good discipline of men, few of whom had two years' service.

The satisfactory manner in which the work was done, appeared to be in no small degree due to the constant and zealous supervision of the officers of the companies.

*England.*

The British new pattern pontoon is a boat with similar decked ends, and is partly decked at the sides. (Plate XL.)

The extreme length is 21 feet 7 inches, its extreme breadth is 5 feet 3 inches, and its depth amidships, including the coamings is 2 feet 8 inches.

The pontoon weighs about 800 lbs., and draws, when floating empty, $2\frac{1}{2}$ inches, and when in bridge, 6 inches. Roughly speaking, every inch of immersion, gives 500 lbs. of buoyancy. The space between two pontoons, in bridge, is always 15 feet, and at this interval, the buoyancy of the pontoon is sufficient to admit of the passage of siege artillery.

The boats consist of a timber framework covered with wood and canvas, put together with a solution of india-rubber.

It is sometimes known as "Clarkson's Material," but differs from the latter in the omission of cork and leather, which were used in the original samples.

Trestles are also carried in the British pontoon train, but the pattern has not yet been finally decided on.

Various expedients have been tried with more or less success, for getting over the defect already mentioned in the two-legged (Birago) trestles, which otherwise are decidedly the favourites with officers commanding pontoon companies.

The impression left on my mind by the trials which took place at Harburg last year, is:—

That we should have in our equipment, trestles capable of being used either as two-legged, or as tripod trestles, as circumstances might require, and trestles of this kind, of which I produce a model, are now being experimentally made at the School of Military Engineering.

The weight of a composite trestle will about equal that of a pontoon.

A unit of pontoon train consists of one troop of Royal Engineers, provided with—

20 pontoon wagons, loaded with pontoons.
4 " " " trestles and superstructure.

The unit (only one is equipped) is sufficient for 100 yards of floating, and 20 yards of trestle bridge.

This does not exceed half the proportion allotted to a single German Army Corps.

Our regular pontoon-train consists of a single troop of Royal Engineers, which is trained in bridging and nothing else; but all the Royal Engineer recruits are instructed in bridging-operations.

So far as the nature of equipment goes, ours is, I think, second to none, if not superior to all, in general fitness for field-service.

The quantity kept in readiness for field-service is, however, very small, and including the reserves in store, for which no men nor horses are set apart, is not sufficient to cross more than one river of ordinary width. The whole equipment, reserves and all, would not cross the Thames at Westminster Bridge, and the Thames at this point is some 50 to 70 yards less wide than the Elbe at Harburg. There two complete bridges were constructed daily.

Our arrangements for annual practice have as yet been incomplete, our pontooning has taken place either in narrow channels of still or comparatively still water, or in the case of those in the Medway, we have not as yet had sufficient equipment of the regulated patterns to make a complete bridge across the river at our practice ground.

The practice, moreover, is very much interrupted and attended with risk, in consequence of the constant passage of barges, which are subject to no special obligation to keep clear of the bridges, and in some cases are only too glad of an excuse for running them down.

For very light infantry bridges, there is not at present any recognised equipment in our service. The want is one which it is very desirable to supply, and the subject is now under consideration. Some infantry pontoons of the type of the old pattern Blanshard Pontoon are in existence, and were found very useful in the Gold Coast Expedition, but they cannot be used singly as boats, and do not supply light troops moving over ground intersected with canals or narrow watercourses, with convenient means of crossing such obstacles.

The late Captain Fowke, R.E. (whose lecture on pontoons at this Institution in 1860,[1] attracted much attention), proposed to supply this

[1] See Journal, Vol. IV., p. 237, *et seq.*

want by collapsing canvas pontoons such as shown in the model, and in certain cases these pontoons, which are very light and portable (total weight of pontoon and superstructure being about 60 lbs.) would be very useful.

Some pontoons of this pattern were sent to the Gold Coast, but they were destroyed by ants and rats before use could be made of them.

The material is therefore unsuited in such a climate.

I have, within the last few days, tried a few light pontoons of the form indicated in the model, designed by Lieutenant Elliot Wood, R.E. These boats used singly, and connected by light ladders, which for telegraph and other purposes are essential for engineer-equipments, promise to provide a safe and steady bridge for infantry in single rank.

Two boats lashed together will form a safe pier for infantry in file and light artillery passed over by hand.

The weight of each pontoon will be about 70 lbs., and of the ladders about 35 lbs. each.

I propose that one boat and two ladders, with a proportion of plank $1\frac{1}{2}$ cwt. in all, shall be carried in each wagon allotted for engineer-equipment.

This will provide means of crossing a watercourse about 18 feet in width.

Trussed girders of the form proposed by Major-General Bainbrigge, R.E., and supplied to the Gold Coast Expedition, and successfully used for connecting some of the piers of the Prah Bridge, would be very useful for passing men or guns over gaps up to 30 feet in width.

The weight of a single girder with roadway 15 inches wide is about 400 lbs. No part exceeds 11 feet in length, or 46 lbs. in weight, so that they are easily packed and carried.

Three 3-inch planks, 12 inches wide and 10 feet long, connected and trussed on the same plan answer equally well, and require less fitting and workmanship. The total weight is about 350 lbs. Of this, the planks weigh 80 lbs. each, 240 lbs. in all. The tension rods and connecting plates, &c., together, weigh about 110 lbs.

Ladders strengthened in the same way would also be useful.

I wish here to state that although for the safe, careful and scientific application of the principles of "bridge-construction" a considerable amount of technical knowledge and experience, which it is the peculiar province of an engineer to acquire, is requisite, yet the subject is of general interest, because the regulations of our service wisely lay down that all Officers, non-commissioned Officers, and men of infantry corps are to have a certain, though limited, amount of practical instruction in field-engineering, including the formation of improvised bridges of simple type.

When I was invited by the Council of this Institution to give a lecture "on Military Bridge-Construction as practised abroad," I replied that I considered it would be more interesting if I were also to say something of what is being done at home, and the Council were good enough to accede to this proposal. I have good reason to believe that in no other nation have the means of instructing the Army at large in field engineering works, been more carefully provided for by the authorities than in our own; but I believe that if contingencies should unfortunately arise to bring our Army into collision with the standing Army of one of the Continental powers, the proportion of trained troops in the engineer branch of our service would, in the absence of any reserve liable to service out of this island, be totally inadequate to meet the demands which would be made on the corps. To provide therefore for such a contingency, every opportunity should be taken of requiring and encouraging the exercise of troops of all arms in simple practical field engineering operations, and of these none are more important than "military bridge-construction."

Owing, I apprehend, to the small number of drilled soldiers in our battalions, and to the many necessary duties and detachments, the number who have received this limited training is not as large as it would have been desirable to instruct.

It is, at the same time, necessary to guard against the tendency to count men twice over by assuming that, because they can be made useful in more than one capacity, they will, in time of war, be available for both.

I have great pleasure in testifying to the interest taken in military bridge-construction by the numerous Officers of all ranks, and non-commissioned Officers and men to whom opportunities of being instructed therein have been afforded at the School of Military Engineering.

Some of these Officers who had previously qualified for Staff employment have informed me, that they attached great value to the practical experience incident to the courses at the School of Military Engineering.

There is no doubt that the opportunities given to Officers of all arms, and especially to candidates for Staff employments of making themselves acquainted with the duties and capabilities of sister services, has, in no small degree, tended to raise the attainments of British Staff Officers to their present high standard.

It is more than ever necessary that Officers in command of mixed forces and Staff Officers should be capable of quickly appreciating the part that should be assigned to each arm in tactical combinations, and by a judicious application of the auxiliary arms, be capable of giving full effect to the offensive power of the *infantry*, on whom in recent, as in all former wars, the brunt of the fighting has fallen.

While advocating greater attention to the training of the troops in military engineering works, I wish to guard against the possible deduction that I consider this instruction should be necessarily imparted at the school with which I am connected, or at any other special school.

I am, on the contrary, of opinion that provided the regimental and company Officers and non-commissioned Officers are, as they should be, competent, instruction is best afforded to the men by those likely to be associated with them on service in the field.

I therefore consider that in this particular matter, the engineering practice of each army division ought to be conducted with the assistance of the engineer troops and equipments which form part of that division, and that the operations of the military schools should be more especially directed to training the Officers and non-commissioned Officers, who are afterwards to act as instructors in their regiments and companies, and the candidates for Staff employment. I am also strongly of opinion that it should be our endeavour to assign to each military corps, duties on the efficient performance of which, their credit should depend, and that in our army there should be a division of labour, corresponding to that which, in the commercial enterprises of this nation, has produced results, *successful*, beyond parallel.

APPENDIX.—*Bridges constructed by the German Army*, 1870.

| No. | Name of River. | Site. | Date of Con-struction. | Date of Demolition. | Length in mètres. | Description of Bridge and *Matériel* used. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | 1870. | | | | |
| 1 | Saar .. | Mettlach ............. | Aug. 3. | | | Pontoon equipment. | |
| 2 | " .. | Schweig............. | " 3. | .. .. | 100 | Scratch materials. | |
| 3 | " .. | Bernenstel............ | " 4. | .. .. | 100 | " " | |
| 4 | Sauer .. | Spachbach............ | " 5. | .. .. | .. .. | Foot bridge. Hop poles. | Eight bridges made here. |
| 5 | " .. | Woerth ............. | " 5. | .. .. | .. .. | Scratch materials. | Five bridges made here. |
| 6 | Nied .. | Etarges ............. | " 12 | .. .. | .. .. | " " ...... | Four bridges made here. |
| 7 | " .. | Parge............... | " 12 | .. .. | .. .. | " " ...... | Two " " " |
| 8 | " .. | Courcelles ........... | " 12 | .. .. | .. .. | " " ...... | Three " " " |
| 9 | Moselle | Pont a Mousson....... | " 13 | .. .. | .. .. | Floating and trestles. Pontoon equipment and scratch materials. | |
| 10 | " | Champy............. | " 13 | .. .. | 86 | Foot bridge. Pontoon equipment. | Afterwards made practicable for waggons. |
| 11 | " | La Lobe............. | " 16 | .. .. | .. .. | Pontoon equipment ...... | |
| 12 | " | Poncé ferme .......... | " 16 | .. .. | .. .. | " " | |
| 13 | " | La Lobe Poste ........ | " 17 | .. .. | 80 | 17 trestles. Scratch materials. | |
| 14 | " | Arry................ | " 17 | .. .. | .. .. | Pontoon equipment. | |
| 15 | " | Corny............... | " 17 | .. .. | .. .. | " " | |
| 16 | Meuse.. | Charny .............. | " 30 | .. .. | .. .. | " " | Two bridges made here. |
| 17 | " .. | Donchery............. | " 30 | .. .. | 45 | and scratch materials. | Two bridges made here. |
| 18 | " .. | Nouvion ............. | Sept. 1. | .. .. | 60 | Pontoon equipment. | |
| 19 | " .. | Sedan............... | " 1 | .. .. | 64 | Pontoon equipment ...... | Two bridges made here. |
| 20 | " .. | Bazeilles ............. | " 2 | .. .. | .. .. | Foot bridges. Scratch materials. | 5 tree bridges over small streams. |

| No. | Name of River. | Site. | Date of Construction. | Date of Demolition. | Length in mètres. | Description of Bridge and *Matériel* used. | Remarks. |
|---|---|---|---|---|---|---|---|
| 21 | Marne . | Trilport.............. | 1870. Sept. 13 | Nov. 26.... | 114 | Pontoon equipment and scratch materials. | |
| 22 | Seine .. | Corbeil............... | „ 17 | Sept. 23.... | 136 | 14 pontoons, 6 trestles.... | A party of Infantry was ferried across in pontoons. |
| 23 | „ .. | Villeneuve St. Georges . | „ 17 | „ 19.... | 135 | 27 pontoons and 2 trestles | Partly constructed under musketry fire. |
| 24 | „ .. | „ „ „ . | „ 18 | „ 30.... | 136 | 29 pontoons............ | The cables had to be protected against ice. |
| 25 | „ .. | Corbeil............... | „ 18 | Dec. 26, broken by floating ice. | 128 | 13 trestles, 25 afterwards added. Scratch materials. | This bridge represented 4,000 hours' work. It was raised 0·55 mètres and the trestles doubled. Loaded with 240 rails. |
| 26 | Marne . | Lagny ............... | „ 18 | Sept. 19.... | .. .. | 9 pontoons. | |
| 27 | Oise .. | Pontoise.............. | „ 18 | „ 19.... | 79 | 13 pontoons and 3 trestles. | This bridge was constructed in 2 hours for the passage of 5th and 6th Divisions of Cavalry. |
| 28 | Seine .. | Corbeil............... | „ 19 | Dec. 24, broken by floating ice. | 101 | 14 trestles. Scratch materials. | Raised and repaired in November. |
| 29 | „ .. | Choisy-le-Roi ......... | „ 19 | Sept. 30.... | 75 | Flying bridge. Pontoon equipment. | Carried 60 men in 4 to 5 minutes, including time for embarking and disembarking. |
| 30 | Marne . | Gournay .............. | „ 19 | Nov. 8..... | 72 | Pontoon equipment. Replaced by improvised trestle bridge, and remade on November 9th with pontoons. | |

| No. | Name of River. | Site. | Date of Con-struction. | Date of Demolition. | Length in mètres. | Description of Bridge and *Matériel* used. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | 1870. | | | | |
| 31 | Seine .. | Triel .................. | Sept. 20 | Sept. 21.... | 126 | 18 pontoons and 7 trestles. Pontoon equipment. | This bridge was constructed in 1½ hours, during the night, and cavalry ferried across on September 19th. |
| 32 | " .. | Les Tuneries ......... | " 20 | Jan. 29 .... | 177 | 31 pontoons and 7 trestles. Pontoon equipment. | Raised 3 mètres on account of high tides. Swung 23 days on account of ice. |
| 33 | Marne . | Pomponne............ | " 21 | Nov. 26 .... | 68 | Pontoon equipment of the vanguard and 5 barges of the Marne. | Constructed in 10 hours. Pontoons successively replaced by barges. Dismantled for one day. |
| 34 | Seine .. | Orly.................. | " 23 | Oct. 31, dismantled during a high tide. | .. .. | Pontoon equipment of Prussians and Wurtemburgians. | While the bridge was being swung, a flying bridge was used. |
| 35 | Oise .. | Beaumont ............ | " 29 | Oct. 4...... | 81 | 16 pontoons, 1 trestle. Pontoon equipment. | Constructed for the expedition against Franco-Tireurs. |
| 36 | Seine .. | Villeneuve St. Georges . | " 30 | Dec. 24 .... | 165 | 50 pontoons in rafts of 6. Double road. | |
| 37 | " .. | " " " . | Oct. 1.. | Oct. 17 .... | 90 | 8 pontoons and 7 trestles. | |
| 38 | " .. | Choisy-le-Roi......... | " 2.. | " 21, dismantled during a high tide. | 116 | Foot bridge. Scratch materials. | |
| 39 | Oise .. | Beaumont ............ | " 4.. | .. .. | 23 | 3 trestles 7 mètres high. Scratch materials. | Permanent bridge repaired; destroyed by the French. |
| 40 | Seine .. | Villeneuve St. Georges . | " 7.. | Dec. 24 .... | 112 | 32 piles, with sleepers at the bottom. Scratch materials. | The superstructure was injured, owing to its low level. The levels of the roads leading to the bridge were too low. |

| No. | Name of River. | Site. | Date of Construction. | Date of Demolition. | Length in mètres. | Description of Bridge and *Matériel* used. | Remarks. |
|---|---|---|---|---|---|---|---|
| 41 | Seine .. | Villeneuve St. Georges . | 1870. Oct. 12. | Dec. 24 .... | 155 | 22 piles. Scratch materials. | Piles were driven 2.30 mètres deep with pile-drivers mounted on rafts. Each pile took 150 hours of work, and the superstructure was 2.70 above water-level. The bridge was loaded with rails. |
| 42 | Loiret.. | Olivet................ | „ 14. | .. .. | .. .. | .. .. .. .. | Substantial bridge repaired. |
| 43 | Oise .. | Pontoise ............ | „ 21. | Oct. 25..... | 82 | 14 pontoons and 3 trestles. Pontoon equipment. | Trestles placed between the regular trestles. |
| 44 | „ .. | „ ............ | „ 21. | „ 21..... | 21 | 4 trestles. Scratch materials. | Permanent bridge repaired. |
| 45 | Loire .. | Toury ............. | „ 25. | .. .. | 330 | Scratch materials ........ | Afterwards lengthened to 375 mètres. |
| 46 | Seine .. | Orly ................ | „ 30. | Nov. 3 ..... | 148 | 21 trestles. Pontoon equipment. | As a flood was expected the flooring was much elevated. |
| 47 | „ .. | „ ................ | Nov. 1. | .. .. | .. .. | Piles. Scratch materials. | Not completed. |
| 48 | „ .. | Corbeil............... | „ 4. | Dec. 1...... | 130 | 21 pontoons, 2 trestles. Pontoon equipment. | |
| 49 | „ .. | Orly ................ | „ 8. | „ 3...... | .. .. | Flying bridge. Pontoon equipment. | Similar to No. 29. |
| 50 | Marne . | Chelles.............. | „ 8. | Nov. 9...... | .. .. | Flying bridge .......... | Substitute for No. 30. |
| 51 | „ . | Gournay ............ | „ 12. | .. .. | 80 | 12 piles. Scratch materials. | Flooring elevated 3 mètres above water-level. |
| 52 | „ . | Lagny ............. | „ 13. | .. .. | 70 | 5 piles and 7 trestles. Scratch materials. | |
| 53 | „ . | Gournay ............ | „ 19. | Dec. 6...... | 98 | Pontoon equipment and scratch materials. | Dismantled because it was under enemy's fire. |

| No. | Name of River. | Site. | Date of Construction. | Date of Demolition. | Length in mètres. | Description of Bridge and *Matériel* used. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | 1870. | | | | |
| 54 | Seine .. | Jurisy ............... | Nov. 12. | Dec. 24, by floating ice. | 156 | 31 pontoons, 1 trestle. Pontoon equipment. | |
| 55 | Marne . | Noisel ............... | Dec. 6 | Jan. 29..... | 87 | 10 pontoons, 2 trestles. Pontoon equipment. | |
| 56 | „ . | Lagny ............... | „ 6. | .. .. | 85 | Scratch materials. | |
| 57 | Loire .. | Gien................. | „ 8. | .. .. | .. .. | Flying bridge. Scratch materials. | The continuations on the banks were 35 mètres long. |
| 58 | „ .. | Blois ............... | „ 10. | Dec. 12... . | .. .. | Piles and boats. Scratch materials. | |
| 59 | „ .. | Beaugency........... | „ 11. | „ 13.... | 240 | Pontoon equipment ...... | Constructed in 10 hours, but the bridge itself only occupied 4 hours. |
| 60 | „ .. | Saint Dié............ | „ 13. | .. .. | .. .. | „ „ ...... | No. 59 repaired. |
| 61 | „ .. | „ „ ............ | „ 14. | .. .. | 320 | „ „ ...... | There is an island here. The bridge from the right bank to the island was made by Prussians, from the left bank to the island by Bavarians. |
| 62 | „ .. | Blois................ | „ 15. | .. .. | 22 | Scratch materials ........ | No. 58 restored. Hessian troops were ferried across in pontoons. |
| 63 | Marne . | Between Vaires and Noisel. | „ 19. | Jan. 28..... | 109 | Prussian and Saxon pontoon equipment. | Dismantled for a few days on account of ice. |
| 64 | Loire .. | Orleans ............ | „ 23. | | | | |
| 65 | Seine .. | Villeneuve St. Georges . | „ 27. | Jan. 19..... | .. .. | Bridge on the ice. Pontoon equipment. | The level of the ice was artificially raised and the surface roughened. |